GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, STATE GEOLOGIST

BULLETIN No. 7.

A PRELIMINARY REPORT

ON A PART OF THE

Water Powers of Alabama

BY

B. M. HALL,

CONSULTING ENGINEER, U. S. GEOL. SURVEY,
FOR GEORGIA, FLORIDA, TENNESSEE AND MISSISSIPPI.

1903

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MONTGOMERY, ALA.:

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1908.

To His Excellency, William D. Jelks, Governor of Alabama:

Dear Sir: I have the honor to transmit herewith a preliminary report on the Water Powers of Alabama, by B. M. Hall, of the United States Geological Survey, Consulting Engineer, Hydrographic Division, for Alabama, Florida, Georgia, Tennessee, and Mississippi.

Our Alabama Geological Survey, in coöperation with the United States Geological Survey, has for a number of years been engaged in a systematic investigation of the Water Resources of the State. In this investigation we have naturally been less interested in that portion of the rainfall which passes back into the atmosphere by evaporation, than in those portions which, temporarily at least, become more or less incorporated with the materials forming our land surface, and which on that account may be considered as forming a part of our territory. And our investigation of this earth water, (to use a term to distinguish it from the atmospheric water), may appropriately be followed along two lines: It may be concerned, 1, with that part of the water which, collecting in rivulets, creeks and rivers, flows on towards the sea by open channels, *i. e.*, the "run-off"; or 2, it may take into account that part which soaks into the ground, and reaches the water courses or the sea only after an underground passage of greater or less duration, *i. e.*, the ground water or the "in-soak," if we may be allowed the use of such a word.

While the proportion of the rainfall which appears in the run-off of the streams varies between very wide limits, depending on the geological formations, the locality, etc., in Alabama on an average, about fifty per cent. of the rainfall is lost by evaporation and the remainder forms the run-off of the streams, and, curiously enough, only a small percentage of this run-off is supplied by the surface water alone, for most of it reaches the water courses by underground seepage.

In the course of this underground circulation the water may reach the surface from springs, from ordinary shallow and deep wells, and from artesian wells, and may be utilized for domestic and municipal water supply, and rarely, in Alabama at least, for irrigation and for power.

The present writer has had charge of this branch of the investigation, and his report on the Artesian and other underground Water Systems of the State is now in manuscript, and practically ready for the printers.

Most of the material for this report has been collected by the Alabama Geological Survey.

The run-off, on the other hand, is utilized for transportation, for domestic and municipal water supply, and for power, and this branch of the subject has been in charge of Mr. Hall, who has for some years been employed by the United States Geological Survey in collecting records of the gage heights, and in making surveys and discharge measurements of the principal streams of Alabama (and adjacent States), from which the values of these streams for the various purposes above enumerated may be closely estimated. In the collection of these data, the Alabama Geological Survey has contributed to the extent of paying the observers of the gage heights at seven stations along Alabama streams, but with this exception and apart from the map, the present Report has been prepared without cost to the State of Alabama. We are also indebted to the United States Geological Survey for most of the illustrations which appear in the body of the Report, and these cuts, as well as most of the data from which this Report has been compiled by Mr. Hall, have been published in the Annual Reports of the Director of the National Geological Survey.

While the present report deals with only one of the many uses to which the run-off of our streams may be put, viz., for the production of power, this is in many respects, especially in Alabama, the most important of these uses, for the great increase in the applications of electricity has of late turned attention to the utilization for its production, of water powers which have heretofore been allowed to run to waste, and there can be little doubt but that in comparatively short time, all the available water power of the State will be turned to account.

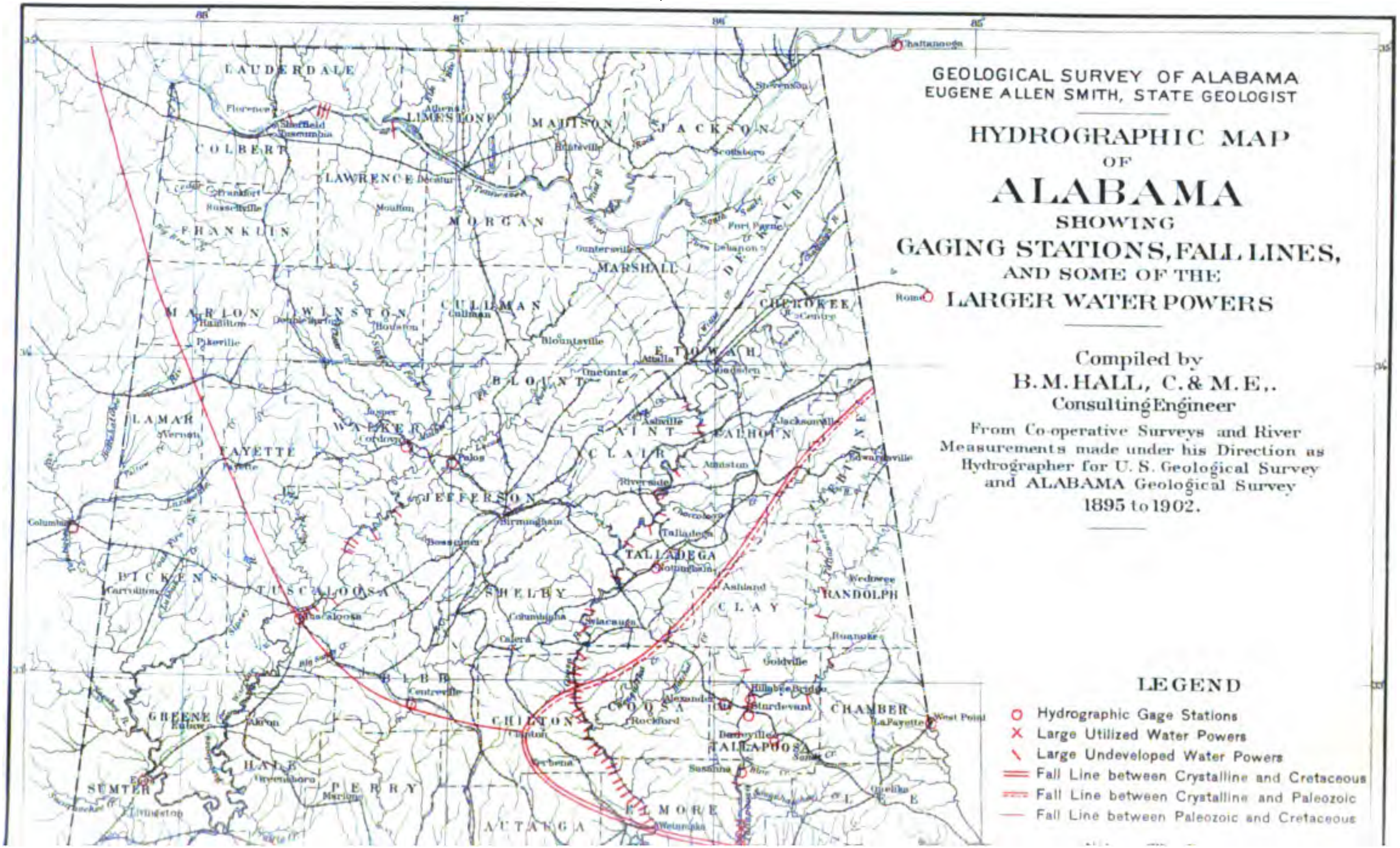
Very respectfully,

EUGENE A. SMITH,

State Geologist

University of Alabama,

Dec. 1, 1902.


GEOLOGICAL SURVEY OF ALABAMA
EUGENE ALLEN SMITH, STATE GEOLOGIST
HYDROGRAPHIC MAP
OF
ALABAMA
SHOWING
GAGING STATIONS, FALL LINES,
AND SOME OF THE
LARGER WATER POWERS
Compiled by
B. M. HALL, C. & M. E.,
Consulting Engineer
From Co-operative Surveys and River Measurements made under his Direction as Hydrographer for U. S. Geological Survey and ALABAMA Geological Survey
1895 to 1902.
LEGEND
Hydrographic Gage Stations
Large Utilized Water Powers
Large Undeveloped Water Powers
Fall Line between Crystalline and Cretaceous
Fall Line between Crystalline and Paleozoic
Fall Line between Paleozoic and Cretaceous
LAUDERDALE
LIMESTONE
MADISON
JACKSON
COLBERT
LAWRENCE
MORGAN
FRANKLIN
MARSHALL
MARION
WINSTON
CULLMAN
CHEROKEE
ETOWAH
BLOUNT
LAMAR
FAYETTE
WALKER
JEFFERSON
TALLADEGA
PICKENS
TUSCALOOSA
SHELBY
CLAY
RANDOLPH
GREENE
BIBB
CHILTON
COOSA
CHAMBERS
HALE
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SUMTER
AUTAUGA
ELMORE
Chattanooga
Rome
Florence
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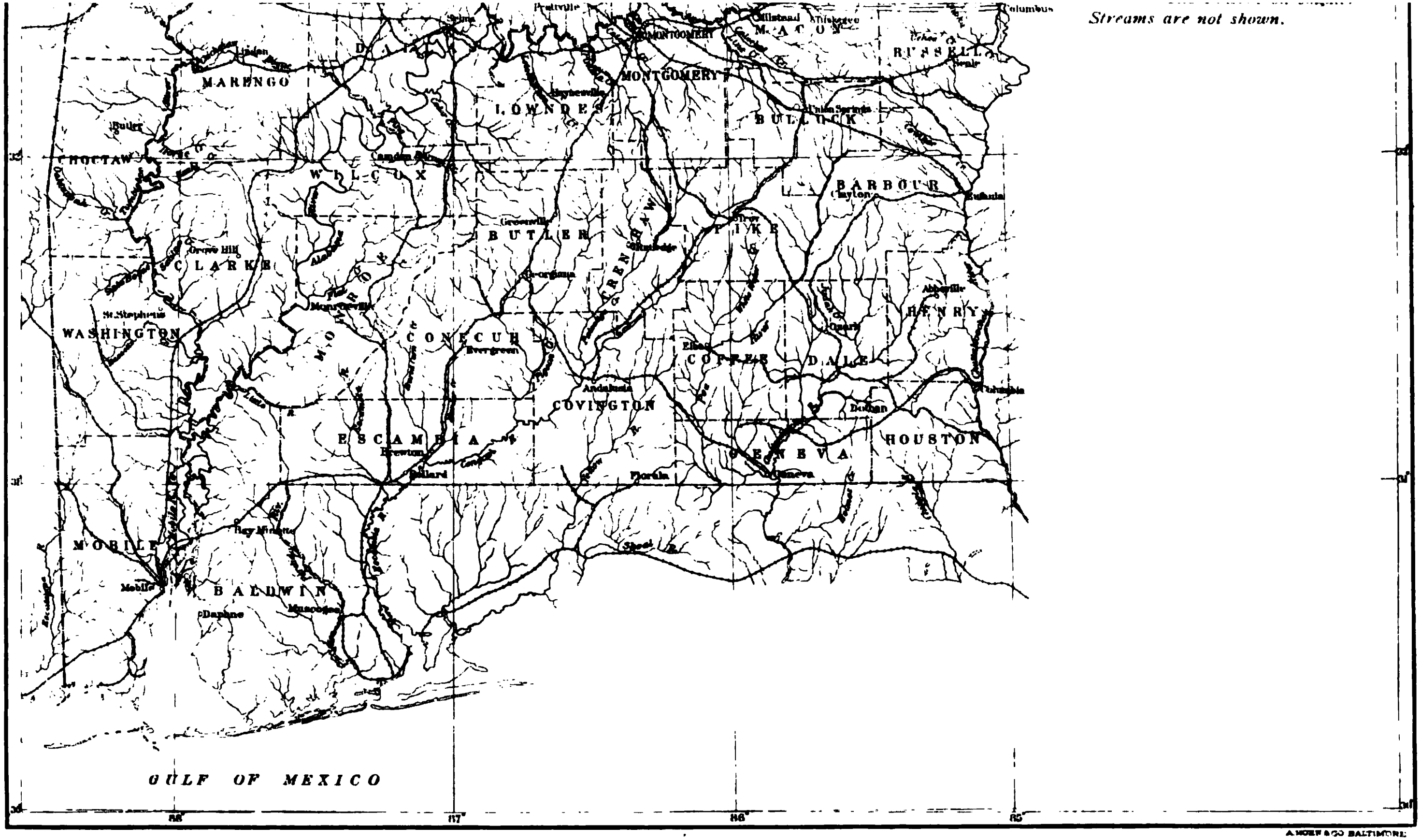
Tuscumbia
Athens
Huntsville
Scottsboro
Stevenson
Decatur
Moulton
Russellville
Guntersville
Fort Payne
Hamilton
Pikeville
Houston
Cullman
Blountsville
Attalla
Gadsden
Oneonta
Jasper
Cordova
Palos
Vernon
Fayette
Ashville
Jacksonville
Anniston
Edwardsville
Birmingham
Bessemer
Riverside
Talladega
Columbus
Carrollton
Tuscaloosa
Columbiana
Sylacauga
Calera
Ashland
Wedowee
Roanoke
Goldville
Centreville
Alexander
Rockford
Hillabee Bridge
Sturdevant
West Point
LaFayette
Eutaw
Akron
Greensboro
Clanton
Verbena
Dadeville
Susanna
Opelika
Marion
Livingston
Wetumpka



A. HOEN & CO. BALTIMORE.

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PREFACE.

Very recently two large Water Powers have been developed on the Tallapoosa River, one of which is at Tallassee, Ala., and the other is three miles above Tallassee. These developments have awakened considerable interest in the undeveloped powers of the State, and this Bulletin undertakes to answer in a general way the numerous inquiries concerning them. Some of the largest of these unpublished powers are:

Power Site No. 3, on Tallapoosa River, at Double Bridges, about ten miles above Tallassee, where a head of 40 feet can be obtained. And other similar powers farther up the river.

Black and Sanford Shoal on Big Sandy Creek, near Dadeville, with 80 feet of fall.

Thirty-one locks on the Coosa River, capable of furnishing 1,300 to 4,500 horse power each, or an aggregate of 100,000 horse power during low season of an ordinary year like 1900.

Seven power sites on the Cahaba River capable of furnishing from 500 to 1,100 horse power each.

Squaw Shoals on the Black Warrior, with 43 feet of fall.

Also the following shoals on the Tennessee River:

Shoal:	Fall in feet.	Minimum H. P. dryest years.	Minimum H. P. average years.
Elk River Shoal	26	15,600	30,550
Big Muscle Shoal	85	51,000	99,375
Little Muscle Shoal	23	13,800	27,025
Colbert Shoal	21	12,600	24,675

These and other powers will be described more fully in Chapters II to VIII.

The water powers of Alabama are conveniently located for running cotton factories and other manufacturing plants, and also for generating electricity that can be transmitted to cities for power, light, etc. The larger powers are all close to water transportation, and are also on important railroads. These advantages will naturally make them more valuable than if they were otherwise located.

B. M. HALL.

Nov. 1, 1902.

CHAPTER I.

DRAINAGE BASINS, STREAMS, AND WATER POWERS.

DRAINAGE BASINS.

The five principal drainage basins of the State are:

First—The Apalachicola Basin, draining to the Chattahoochee and Apalachicola River, and entering the Gulf at Apalachicola, Fla.

Second—The Choctawhatchee Basin, draining to the Gulf through Choctawhatchee Bay.

Third—The Pensacola Basin, draining to Pensacola Bay and Perdido Bay, near Pensacola, Fla.

Fourth—The Mobile Basin, including the waters of Tallapoosa, Coosa, Cahaba, Alabama, Warrior, and Tombigbee Rivers, and draining into the Gulf at Mobile, Ala.

Fifth—The Tennessee Basin, draining into the Tennessee River, and thence through the Mississippi to the Gulf at New Orleans.

The water powers of the State are mainly in the Mobile and Tennessee Basins, which practically cover the entire State, except a small area in the southeast corner.

The area of crystalline rocks in Alabama is a triangle on the east side of the State, including Cleburne, Randolph, Chambers, Lee, Tallapoosa, Clay, Coosa, and parts of Elmore, Chilton, and Talladega counties. The "fall line," or escarpment dividing the Crystalline region from the Cretaceous formation of the Coastal plain on the southwest, runs from Columbus, Ga., crossing the Tallapoosa River at Tallassee, and the Coosa at Wetumpka. The northwestern boundary of the area of the Crystalline rocks which divides it from the Paleozoic formations, recrosses the Coosa River near Marble Valley postoffice, in Coosa county, and runs in a northeasterly direction towards Cedartown, Ga., crossing the Alabama line near Warner.

The line between the Paleozoic region and the Cretaceous formation runs from a point near Strasburgh, in Chilton county,

in a northwesterly direction to Tuscaloosa, thence in a northerly direction to a point near Tuscumbia, and thence northwesterly to the Mississippi line.

The southwestern boundary of the Cretaceous passes from Fort Gaines, approximately, through Clayton, Troy, Snow Hill, and Livingston, in a northwesterly direction.

It may be said in a general way that the streams have their greatest falls in passing from an older to a younger geological formation. Tallassee Falls, on the Tallapoosa, and Wetumpka Falls, on the Coosa, are made in passing from the Crystalline to the Cretaceous. Those on Talladega Creek and other small streams in entering the Coosa Valley from the southeast in Talladega, Calhoun, and Cleburne counties, are from the Crystalline to the Paleozoic. The shoals above Centerville, on the Cahaba, above Tuscaloosa, on the Black Warrior, and near Tuscumbia, on the Tennessee River, are made in passing from the Paleozoic to the Cretaceous. As the Coosa River runs off of the Paleozoic on to the Crystalline near Talladega Springs, the shoals above this point reverse the general order by being made in passing from a younger to an older formation.

STREAMS AND WATER POWERS.

The following is a statement, according to water--shed, of the important streams and such data concerning them as can be compiled from the work of the Alabama Geological Survey, the United States Weather Bureau, and the United States Engineering Corps, combined with the hydrographic investigations of the United States Geological Survey under the direction of the compiler of this report. Aside from certain surveys made to obtain maps and profiles of Tallapoosa River and Big Sandy Creek, the work done by the Hydrographic Division of the United States Geological Survey in this State deals exclusively with the amount of water flowing in the streams, and is intended to give a safe basis for calculation of low water volumes at all seasons of the year, and for several consecutive years, in order to arrive at their value for water power, irrigation, municipal supply, mining, navigation, etc. In order to do this certain convenient stations have been established on important rivers. At each of these stations a gage rod is set to show the fluctuations of the streams; and a gage reader is employed to observe the height of the water every morning at the same hour,

and to make a weekly report of the same to the Hydrographer-in-charge. As far as possible the river stations of the United States Weather Bureau and the United States Engineer Corps have been utilized for this purpose. From time to time the Hydrographer or one of his field assistants, visits the station and makes an accurate meter discharge measurement of the stream, noting the height of the water on the gage at the time the discharge measurement is made. After a number of such discharge measurements have been made at different gage-heights, a rating table is made from the data thus obtained, which gives the amount of water ffowing in the stream, at that station, for any gage-height shown on the rod. Thus, by inspection of the table of daily gage-heights, the flow of the stream is shown for every day in the year, or years, covered by the observation of gage-height. At seasons of uniform low water, when the daily fluctuations of the rod are very slight for weeks at a time, discharge measurements are made of the stream at many points above and below the gage station in order to establish a relation between the discharge at these points and at the station. In like manner the principal tributaries are measured for the same purpose, where it is practicable to do so. In this way it is possible to arrive at a close estimate of the flow of all the streams of the water-shed, and make a rating of the gage for each that will represent its flow under average conditions, not including the floods caused by local rains. Such tributaries as have not been measured can be estimated by water-shed comparison with similar tributaries that have been measured.

In the following statement the actual gage-heights and discharge measurements are given in order to show the data upon which the conclusions are based. The regular gage stations that have been utilized are:

Station.	*Stream.*	*Observer.*	*Paid by.*
1—Milstead, Ala......	Tallapoosa River	Seth Johnson...	Ala. Geo. Sv.
2—Sturdevant, Ala....	Tallapoosa River	B. F. Neighbors.	Ala. Geo. Sv.
3—Dadeville, Ala......	Big Sandy Creek	T. H. Finch.....	Ala. Geo. Sv.
4—Alexander City, Ala.	Hillabee Creek..	J. H. Chisolm...	Ala. Geo. Sv.
5—Nottingham, Ala...	Talladega Creek.	R. M. McClatchy.	Ala. Geo. Sv.
6—Riverside, Ala......	Coosa River.....	J. W. Foster.....	Ala. Geo. Sv.
7—Cordova, Ala.......	Black Warrior R	A. B. Logan.....	Ala. Geo. Sv.
8—Montgomery, Ala...	Alabama River..	U. S. W. B......	U. S. W. B.
9—Selma, Ala.........	Alabama River..	U. S. W. B......	U. S. W. B.
10—Tuscaloosa, Ala....	Black Warrior R	W. S. Wyman, Jr	U. S. Eng. C.
11—Epes, Ala..........	Tombigbee River	J. C. Horton.....	A. G. S. Ry.
12—Rome, Ga..........	Coosa River.....	W. M. Towers...	U. S. W. B.
13—Chattanooga, Tenn.	Tennessee River.	U. S. W. B......	U. S. W. B.

As the investigations in this State have been confined so far mainly to the Mobile and Tennessee basins, only the streams of these basins will be considered in the following discussion. It is to be remembered that from West Point, Ga., southwards, the line of Alabama is on the west bank of the Chattahoochee River, along the line where ordinary vegetation ceases to grow. This leaves all of the water power of the main stream on Georgia territory. There are many creeks flowing into the river from Alabama, some of which have considerable fall, as they come from a high plateau. Holland Creek, opposite Columbus, Ga., furnishes the Columbus water supply by gravity, having a fall of 117 feet in less than four miles. No doubt many of the others have as much fall, but as they have not been examined, a report on them cannot be made at present, but a recent reconnoissance along the Chattahoochee gives the following estimate of power obtained from some of them, 12 hours per day for each foot of fall, if the water is stored during the 12 idle hours:

Big Uchee Creek, Russell County	7 H. P. per foot of fall.
Ihagee Creek, Russell County	2 H. P. per foot of fall.
Hatchechubbee Creek, Russell County	7 H. P. per foot of fall.
Cowikee Creek, Barbour County	11 H. P. per foot of fall.
Yattayabba Creek, Henry County	9 H. P. per foot of fall.
Omussee Creek, Henry county	7 H. P. per foot of fall.

EXPLANATION OF STATION RECORDS AND TABULAR STATEMENTS DEDUCED THEREFROM.

GAGE HEIGHTS.

The "Table of Gage Heights" is a record of the height of water on a gage rod, graded to feet and hundredths of a foot, set into the river vertically, and fastened permanently to a convenient tree or pier. The rod is read every day in the year, at the same time of day, which is about 8 o'clock in the morning. Inches are not used in these records, as the daily height of water on the gage is written in feet and decimals of a foot.

DISCHARGE MEASUREMENTS.

These records show the date, the gage height at time of measurement, and the amount of water in cubic feet per second, or "second-feet," that is found by the measurement to be flowing in the river. (Second-feet means the same as cubic feet per second.) If we imagine a small stream filling a rectangular flue 1 foot wide and 1 foot deep, we have a stream whose sectional area is 1 square foot. The volume of this stream will vary in proportion to the speed with which the water flows through the flume. If the water is moving at a velocity of 1 foot per second, the flow or volume of water is 1 cubic foot per second, and would fill a vessel 5 feet wide, 5 feet long, and 4 feet deep in just 100 seconds, as such a vessel would hold 100 cubic feet of water. If the water in the flume 1 foot wide and 1 foot deep flows with a velocity of 2 feet per second, the volume will be 2 cubic feet per second, or 2 second-feet, and so on for any other velocity. In the same way if the flume is 20 feet wide, and 5 feet deep, its sectional area will be 100 square feet, and if the average velocity is 3 feet per second, the volume will be 300 cubic feet per second, or 300 second-feet. In each of the discharge measurements here enumerated, a cross-section of the stream is measured, and velocities taken with an electric current-meter at many points of the cross-section. Instead of multiplying the entire cross-section by an average velocity, the area was divided up into a large number of small sections by soundings from 5 to 10 feet apart, and the area of each of the small sections multiplied by the velocity at the small section, thus giving the second-feet flowing in each small section. The sum of the discharges of all the small sections makes the total discharge of the stream.

RATING TABLE.

This is a table showing the discharges in second-feet (cubic feet per second) for all stages of water on the gage. Hence when the gage heights are known, the corresponding discharges can be taken from the rating table and written opposite each daily gage height, thus giving the flow in cubic feet per second on each day in the entire year.

ESTIMATED MONTHLY DISCHARGE, ETC.

This table gives in the first three columns, the maximum, minimum, and mean discharge for each month in cubic feet per second (second feet.) Column No. 4 gives the "total acre feet" flowing down the stream during each month. An "acre-foot" is the amount of water that would be necessary to cover one acre with a depth of one foot, which is 43,560 cubic feet. It furnishes a convenient unit for storage, where the water is to be used for irrigation. A cubic foot is practically 7.48 gallons, and is usually estimated at 7.5 gallons. An acre-foot is 43,560 cubic feet, or 320,851 gallons. One cubic foot per second flowing for 24 hours will cover an acre to a depth of 1.98 feet. It is therefore customary in round numbers to state that a cubic foot per second for a day of 24 hours is equivalent to 2 acre feet. Now, as one inch of rainfall per hour falling for 12 hours would cover one acre a foot deep, it is evident that rainfall at the rate of 1 inch per hour will produce a flow of 1 cubic foot per second, or 2 acre feet per 24 hours for each acre of watershed, no allowance being made for evaporation or percolation. It is also convenient to remember that 1,000,000 gallons in a reservoir are equal to a little more than 3 acre feet (3.069). In a general way it may be said that water stored in reservoirs is reckoned in acre-feet for irrigation, cubic feet for water power, and in millions of gallons for city water supply.

Columns 5 and 6 give the "run-off" from the drainage area. The run-off in inches and decimals of an inch is given, just as rainfall is given. For instance, a run-off of 2.23 inches from a given drainage area, means that enough water ran off during the month to have covered the entire drainage area or water-shed to a depth of 2.23 inches. This is convenient in estimating the proportion of the rain-fall on any drainage area that can be stored for irrigation, city water supply, or other purposes. The run-off in second-feet per square mile of drainage area, is obtained by dividing the mean discharge for the month by the number of square miles in the drainage area, and is useful in estimating the mean discharge of a tributary whose drainage area is known, and in comparing different drainage areas. The "run-off" is not a fixed percentage of the rainfall, but is that part of the rainfall which is not lost by evaporation into the air, or by percolation in subterranean outlets. Being a remainder and

not a percentage, it necessarily forms a much larger proportion of a heavy annual rainfall than it does of a small annual rainfall. For instance, in the Crystalline region of Georgia or Alabama where the annual precipitation is 45 to 55 inches, the run-off from the water-sheds is equal to fully one-half of the rainfall, while in regions having a precipitation of only 10 to 20 inches annually, the run-off is frequently less than one-fifth of the rainfall. Again, the geological character of the water-shed makes a vast difference in the run-off, even where the annual rainfall is the same, and where practically the same conditions of climate, topography, forest area and cultivation exist. There will be a smaller run-off from the water-shed having permeable geological strata underneath it, into which a part of the rain water can percolate, and furnish the supply to artesian wells in the lower country under which the same strata run, without regard to surface topography. In a comparison of two such water-sheds, one in the crystalline region, and the other in a regularly stratified formation, the difference of run-off should form a basis for estimating the artesian supply obtainable from the latter as a fountain head.

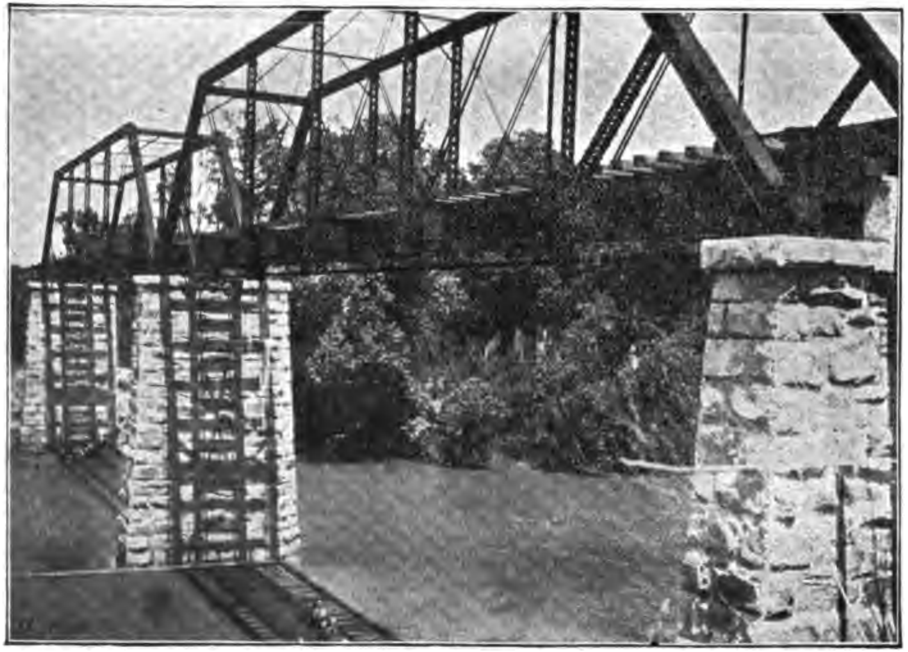

PLATE A. Bridge at Milstead on Tallapoosa River.

CHAPTER II.

TALLAPOOSA RIVER AND TRIBUTARIES.

1. TALLAPOOSA RIVER AT MILSTEAD, ALABAMA.

Tallapoosa River rises in the west-central part of Georgia and flows in a southwesterly direction into Alabama, where it joins the Coosa, to form Alabama River, 6 miles above Montgomery, Alabama. Its upper tributaries drain an area between the Chattahoochee and Coosa basins. At Tallassee, Alabama, it crosses the southern fall line. The shoals at this place have a fall of 60 feet, forming an obstruction to navigation. The drainage area is largely wooded, with cultivated fields at short intervals. A gaging station was established at Milstead on August 7, 1897, at the bridge of the Tallassee & Montgomery Railway, about one-fourth of a mile from Milstead, Alabama. The bridge is of iron, two spans of about 155 feet each, with short wooden trestles at each end. The initial point of measurement is the end of the iron bridge, left bank, downstream side. The rod of wire gage is fastened to outside of guard rail on downstream side of bridge. The bench mark is top of second cross beam from left-bank pier, downstream end, and is 60.00 feet above datum. The channel is straight at the bridge, and bends above and below. The current is sluggish at low water and obstructed by center pier of bridge. The banks are high, but overflow at extreme high water for several hundred feet on each side. The bed is fairly constant, and all water is confined to the main channel by railroad embankments. The observer is Seth Johnson, a farmer and fruit grower, Milstead, Alabama. The plate A opposite shows this station.

The following discharge measurements were made during 1897 by Max Hall:

May 3, gage height, 6.20 feet; discharge, 7,333 second-feet.
July 15, gage height, 1.95 feet; discharge, 1,692 second-feet.
August 7, gage height, 2.42 feet; discharge, 2,292 second-feet.
September 4, gage height, 1.60 feet; discharge, 1,271 second-feet.
November 23, gage height, 1.20 feet; discharge, 677 second-feet.
December 16, gage height, 3.58 feet; discharge, 4,210 second-feet.

***Daily gage height, in feet, of Tallapoosa River at Milstead, Alabama, from August to December, 1897.**

Day.	Aug.	Sept.	Oct.	Nov.	Dec	Day.	Aug.	Sept.	Oct.	Nov.	Dec
1	......	1.70	0.80	0.90	1.50	17	1.90	1.10	0.80	1.20	2.80
2	......	1.80	.80	1.00	1.50	18	2.20	1.00	.90	1.20	2.40
3	......	1.60	.80	1.10	1.50	19	2.80	1.10	.90	1.20	2.10
4	......	1.60	.70	1.10	1.60	20	9.70	1.10	.90	1.10	2.00
5	......	1.60	.70	1.10	1.80	21	7.40	1.10	.80	1.20	1.90
6	......	1.40	.70	1.10	2.00	22	8.50	1.00	.80	1.10	2.00
7	2.45	1.40	.70	1.10	2.10	23	5.30	1.00	.90	1.10	2.40
8	1.90	1.30	.60	1.10	2.00	24	3.40	1.00	.90	1.20	2.40
9	1.70	1.20	.70	1.20	1.90	25	2.90	1.00	.80	1.20	2.40
10	1.50	1.20	.70	1.20	1.90	26	2.80	1.00	.90	1.20	2.80
11	1.50	1.10	.70	1.30	1.90	27	2.30	1.00	.90	1.20	2.60
12	2.70	1.10	.70	1.30	2.00	28	2.00	.90	.90	1.60	2.60
13	2.20	1.10	.70	1.30	1.90	29	1.80	.90	.90	1.50	2.80
14	2.00	1.10	.80	1.30	5.50	30	1.70	.80	.90	1.50	2.20
15	1.80	1.40	.80	1.20	4.70	31	1.70	......	.90	......	2.40
16	1.60	1.20	.80	1.20	3.60						

*See explanation, pages 11 to 14.

Rating table for Tallapoosa River at Milstead, Alabama, for 1897.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet*	*Feet.*	*Second-feet*	*Feet*	*Second-feet.*	*Feet.*	*Second-feet.*
0.5	330	1.5	1,070	3.0	3,129	5.0	5,909
0.6	350	1.6	1,200	3.2	3,407	5.2	6,187
0.7	380	1.7	1,333	3.4	3,685	5.4	6,465
0.8	420	1.8	1,467	3.6	3,963	5.6	6,743
0.9	470	1.9	1,600	3.8	4,241	5.8	7,021
1.0	530	2.0	1,733	4.0	4,519	6.0	7,299
1.1	620	2.2	2,007	4.2	4,797	7.0	8,689
1.2	720	2.4	2,285	4.4	5,075	8.0	10,079
1.3	830	2.6	2,573	4.6	5,353	9.0	11,469
1.4	950	2.8	2,851	4.8	5,631		

NOTE—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1898 by Max Hall and others:

Jan. 19—Gage height, 2.13 feet; discharge, 1,889 second-feet.
Feb. 19—Gage height, 2.20 feet; discharge, 2,045 secod-feet.
March 18—Gage height, 2.56 feet; discharge, 2,646 second-feet.
April 26—Gage height, 5.83 feet; discharge, 6,648 second-feet.
May 17—Gage height, 1.55 feet; discharge, 1,059 second-feet.
June 22—Gage height, 3.05 feet; discharge, 3,421 second-feet.
July 7—Gage height, 1.62 feet; discharge, 1,262 second-feet.
Aug. 5—Gage height, 13.67 feet; discharge, 15,295 second-feet.
Sept. 3—Gage height, 2.76 feet; discharge, 3,010 second-feet.
Nov. 29—Gage height, 5.16 feet; discharge, 5,477 second-feet.

Daily gage height, in feet, of Tallapoosa River at Milstead, Alabama, for 1898.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	2.90	2.30	1.90	4.80	2.60	1.10	1.50	3.60	4.30	1.30	2.30	4.90
2	1.90	2.20	1.80	3.90	[illegible]	1.10	1.30	2.90	3.20	1.30	2.20	4.40
3	1.80	2.10	1.90	3.10	2.20	1.10	1.20	2.80	2.70	1.40	2.20	7.70
4	1.70	2.00	2.40	3.00	2.10	1.10	1.10	11.50	2.70	16.00	2.10	10.00
5	1.70	2.00	2.90	17.00	2.00	1.10	1.20	14.00	4.00	32.00	2.10	8.60
6	1.80	2.00	2.80	18.80	2.00	1.10	1.30	8.90	4.60	23.50	2.20	6.80
7	1.80	2.00	2.50	12.10	1.90	1.00	1.70	10.10	6.00	16.40	2.70	5.60
8	1.80	2.00	2.30	7.10	1.90	.90	2.90	8.50	5.60	22.80	4.20	4.80
9	1.90	2.00	2.20	5.20	1.80	.90	4.90	7.90	4.50	14.00	2.80	4.60
10	1.90	1.90	2.00	4.00	1.80	.90	3.60	5.30	3.50	7.90	3.00	6.70
11	1.90	1.90	2.00	3.40	1.70	.80	4.40	17.30	2.90	5.90	7.10	6.10
12	2.40	1.90	2.00	3.10	1.70	.90	2.00	22.60	2.60	4.90	5.10	5.50
13	2.40	1.90	1.90	3.00	1.70	[illegible]	1.70	10.10	2.50	3.80	5.00	5.00
14	2.60	1.90	1.90	2.90	1.60	1.20	2.70	7.70	2.40	3.40	5.90	4.40
15	2.40	1.80	2.70	2.80	1.60	1.10	3.50	6.10	2.20	3.00	5.50	4.00
16	2.40	1.80	2.60	2.60	1.60	1.20	5.10	4.20	2.00	2.70	5.40	3.80
17	2.40	1.80	2.50	2.40	1.60	2.10	2.40	3.40	1.80	2.60	6.20	3.60
18	2.30	1.90	2.60	2.40	1.60	1.80	2.80	2.80	1.70	4.40	6.10	3.40
19	2.20	2.20	2.50	2.20	1.50	1.40	3.05	2.60	1.60	5.00	14.40	4.30
20	2.20	2.30	2.40	2.40	1.50	1.40	2.30	2.80	1.60	4.40	12.20	7.60
21	3.10	2.30	2.20	2.80	1.40	1.40	1.90	2.50	1.50	3.70	10.00	7.00
22	3.10	3.10	3.00	2.70	1.40	3.00	1.60	2.30	1.50	3.30	8.00	5.20
23	3.00	2.00	1.90	2.80	1.30	2.40	1.60	2.20	1.50	3.10	10.00	4.40
24	2.90	2.00	1.90	14.50	1.30	2.20	1.50	2.00	1.60	2.70	8.80	6.40
25	2.60	1.90	1.80	11.60	1.20	2.10	1.50	2.10	1.80	2.60	7.90	6.00
26	2.90	1.80	1.80	5.90	1.20	1.80	2.50	8.10	2.00	2.50	5.30	4.60
27	3.60	1.90	1.80	4.30	1.20	1.50	2.60	10.20	1.80	2.40	4.60	4.20
28	3.90	1.90	1.70	3.30	1.30	1.80	4.10	8.40	1.60	2.40	4.10	3.90
29	3.10	......	2.20	2.95	1.20	2.70	2.80	7.00	1.50	2.40	4.90	3.80
30	2.65	......	4.20	2.80	1.20	1.90	2.90	5.20	1.50	2.40	5.40	3.70
31	2.40	......	5.30	......	1.10	.. ..	3.80	5.10	......	2.30	......	4.00

Rating table for Tallapoosa River at Milstead, Alabama, for 1898.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Ft.*	*Feet.*	*Second Ft.*
0.8	540	2.4	2,380	8.0	8,820
0.9	655	2.5	2,495	8.5	9,395
1.0	770	2.6	2,610	9.0	9,970
1.1	885	2.7	2,725	9.5	10,545
1.2	1,000	2.8	2,840	10.0	11,120
1.3	1,115	2.9	2,955	10.5	11,695
1.4	1,230	3.0	3,070	11.0	12,270
1.5	1,345	3.5	3,645	11.5	12,845
1.6	1,460	4.0	4,220	12.0	13,420
1.7	1,575	4.5	4,795	12.5	13,995
1.8	1,690	5.0	5,370	13.0	14,570
1.9	1,805	5.5	5,945	13.5	15,145
2.0	1,920	6.0	6,520	14.0	15,720
2.1	2,035	6.5	7,095	14.5	16,295
2.2	2,150	7.0	7,670	15.0	16,870
2.3	2,265	7.5	8,245		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1899 by Max Hall:

April 17—Gage height, 6.34 feet; discharge, 7,444 second-feet.
April 18—Gage height, 5.63 feet; discharge, 6,853 second-feet.
May 17—Gage height, 2.80 feet; discharge, 3,000 second-feet.
June 26—Gage height, 2.05 feet; discharge, 1,847 second-feet.
September 9—Gage height, 1.36 feet; discharge, 1,016 second-feet.
November 8—Gage height, 1.25 feet; discharge, 972 second-feet.
December 18—Gage height, 2.66 feet; discharge, 2,844 second-feet.

Daily gage height, in feet, of Tallapoosa River, at Milstead, Alabama, for 1899.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	5.00	17.00	27.00	18.00	4.30	2.40	2.80	3.00	2.40	0.70	1.50	2.40
2	4.60	11.60	19.00	12.20	4.00	2.90	2.30	2.70	2.30	.70	1.40	2.50
3	3.90	24.50	13.50	6.50	3.90	2.40	1.90	3.10	2.10	.80	1.40	2.60
4	3.90	20.00	9.60	6.40	3.80	2.40	1.80	3.10	2.00	.90	1.30	2.60
5	3.90	12.90	14.20	8.50	3.70	2.30	1.60	2.50	1.80	1.00	1.30	2.90
6	3.80	11.90	13.20	9.70	3.60	2.20	1.50	2.30	1.60	1.40	1.20	2.20
7	7.40	17.50	10.10	10.30	3.50	2.10	1.50	2.20	1.60	1.40	1.20	2.00
8	8.00	27.00	8.60	13.00	3.60	2.00	2.00	2.00	1.40	1.30	1.20	1.90
9	7.10	19.00	7.70	13.00	3.50	1.90	2.20	1.80	1.40	1.30	1.20	1.80
10	6.40	13.80	7.20	11.20	3.40	1.70	2.00	1.60	1.30	1.30	1.20	1.90
11	18.50	10.00	6.80	8.40	3.30	1.90	1.80	1.50	1.20	1.40	1.30	2.00
12	16.80	8.30	6.60	7.00	3.20	2.00	1.70	1.70	1.20	1.40	1.30	15.20
13	13.00	7.40	6.50	6.50	3.10	2.00	1.50	1.60	1.20	1.30	1.30	13.20
14	11.60	7.00	6.40	6.20	3.10	2.70	1.40	1.60	1.10	1.30	1.30	8.20
15	9.40	6.10	7.20	6.00	3.00	2.70	1.30	1.50	1.00	1.20	1.30	5.00
16	7.80	10.40	12.20	7.10	2.90	2.60	1.30	4.00	1.00	1.10	1.30	3.70
17	12.70	11.50	11.00	6.60	2.80	2.10	1.20	3.90	1.00	1.20	1.60	3.00
18	10.00	10.60	10.20	5.60	2.70	1.90	1.10	2.20	1.00	1.10	1.50	2.60
19	8.00	9.30	14.80	5.50	2.60	1.80	1.60	1.90	1.10	1.20	1.50	2.50
20	6.50	8.30	13.90	5.40	2.50	1.80	1.40	1.70	1.00	1.30	1.50	2.70
21	5.70	8.30	10.40	5.20	2.60	1.70	8.40	1.50	.90	1.40	1.40	2.70
22	5.30	8.40	8.30	5.00	2.70	1.50	16.75	1.60	1.00	1.50	1.40	2.70
23	5.10	7.60	8.10	4.90	2.60	1.50	14.00	2.00	1.00	1.60	1.60	2.60
24	5.20	6.90	12.70	6.00	3.30	1.50	16.95	2.60	.90	1.80	1.80	9.30
25	5.20	6.40	8.70	10.00	4.60	1.50	7.90	1.90	.90	1.50	2.20	9.40
26	5.10	6.30	7.30	7.50	3.30	2.00	6.70	1.80	.90	1.40	4.60	7.20
27	4.80	25.00	6.90	6.60	2.80	2.50	6.80	3.70	.90	1.30	6.20	5.00
28	4.70	37.00	6.80	5.80	2.60	2.50	8.40	2.80	.80	1.20	4.80	4.00
29	5.10	......	9.00	4.90	2.50	2.20	10.10	2.10	.80	1.50	3.60	3.50
30	5.20	......	8.90	4.60	2.60	2.70	5.40	1.90	.80	1.50	2.80	3.10
31	6.50	......	13.85	......	2.50	.. ..	4.40	2.30	......	1.60	......	2.90

Rating table for Tallapoosa River at Milstead, Alabama, for 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Feet.*	*Feet.*	*Second Ft.*
0.7	320	6.5	7,437	17.5	20,977
0.8	430	7.0	8,052	18.0	21,582
0.9	550	7.5	8,667	18.5	22,179
1.0	672	8.0	9,282	19.0	22,812
1.1	795	8.5	9,897	19.5	23,427
1.2	918	9.0	10,512	20.0	24,042
1.3	1,041	9.5	11,127	20.5	24,657
1.4	1,164	10.0	11,742	21.0	25,272
1.5	1,287	10.5	12,357	21.5	25,887
1.6	1,410	11.0	12,972	22.0	26,502
1.7	1,533	11.5	13,587	22.5	27;117
1.8	1,656	12.0	14,202	23.0	27,732
1.9	1,779	12.5	14,817	23.5	28,347
2.0	1,902	13.0	15,432	24.0	28,962
2.5	2,517	13.5	16,047	24.5	29,577
3.0	3,132	14.0	16,662	25.0	30,192
3.5	3,747	14.5	17,277	25.5	30,807
4.0	4,362	15.0	17,892	26.0	31,422
4.5	4,977	15.5	18,507	26.5	32,037
5.0	5,592	16.0	19,122	27.0	32,652
5.5	6,207	16.5	19,737	27.5	33,287
6.0	6,822	17.0	20,352	27.9	33,779

NOTE—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

During the year 1900 the following discharge measurements were made by Max Hall:

Feb. 23—Gage height, 9.20 feet; discharge, 9,956 second-feet.
March 5—Gage height, 6.70 feet; discharge, 7,088 second-feet.
Dec. 3—Gage height, 2.95 feet; discharge, 3,031 second-feet.

Daily gage height, in feet, of Tallapoosa River near Milstead, Alabama, for 1900.

Day.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
1........	2.70	2.50	13.20	5.50	6.30	2.60	9.00	6.50	2.70	1.80	2.50	3.30
2........	2.60	2.40	13.10	5.30	5.90	2.70	9.10	4.50	8.00	1.60	3.30	3.30
3........	2.40	2.30	10.70	5.00	5.40	3.00	10.60	3.50	8.10	1.50	6.10	3.30
4........	2.30	4.50	8.00	5.30	4.90	3.50	7.10	2.80	4.40	1.80	6.50	3.50
5........	2.30	4.20	6.80	4.80	4.70	3.30	8.00	2.70	3.00	3.30	7.10	3.90
6........	2.30	4.30	6.10	4.70	3.90	3.50	5.20	2.50	2.40	6.40	5.50	3.90
7........	2.20	4.40	5.60	4.60	3.80	3.30	4.40	2.30	2.20	3.40	4.10	3.80
8........	2.20	3.80	10.90	4.60	3.70	5.90	4.00	2.20	2.00	3.20	3.50	3.80
9........	2.20	5.20	13.80	4.50	3.60	9.70	3.50	2.10	1.80	2.60	3.00	3.10
10........	2.20	8.90	12.70	4.60	3.50	6.90	7.60	2.00	1.70	2.60	2.90	3.10
11........	2.60	19.00	10.00	5.50	3.80	5.60	5.50	1.90	1.70	3.00	2.70	2.80
12........	7.30	30.00	7.90	10.60	3.20	4.60	4.10	1.90	1.60	2.80	2.60	2.80
13........	6.00	43.25	6.60	11.50	3.10	5.30	4.70	1.80	1.50	3.40	2.60	2.80
14........	4.50	42.00	5.90	9.00	3.00	4.00	6.70	1.90	1.50	3.30	2.50	7.70
15........	4.00	31.90	5.40	6.60	2.90	3.80	6.00	2.20	14.00	3.30	2.50	9.10
16........	3.40	22.80	7.00	5.30	2.90	3.50	5.10	2.70	25.60	2.70	2.50	7.30
17........	3.00	13.50	7.20	4.70	2.80	4.50	3.80	3.10	18.00	2.70	2.50	5.20
18........	2.90	8.90	5.60	13.90	2.80	5.90	3.80	2.50	11.00	2.20	2.50	4.20
19........	3.70	7.00	5.40	17.00	2.80	5.00	3.60	4.00	5.30	2.10	2.50	4.00
20........	9.50	6.10	6.00	15.00	2.90	5.90	3.10	4.20	3.60	2.00	2.50	8.60
21........	7.50	6.50	11.40	16.90	2.80	5.90	3.00	2.50	3.00	1.90	2.50	17.00
22........	5.90	9.80	10.50	13.30	3.00	5.50	2.80	2.20	2.50	2.00	4.00	13.50
23........	4.60	9.50	7.60	10.30	3.10	5.40	2.70	2.00	2.30	4.80	4.00	10.40
24........	3.90	8.90	15.50	13.20	3.40	20.00	2.60	2.30	2.20	12.10	3.90	11.30
25........	3.50	8.40	15.20	12.50	3.50	25.04	2.50	3.30	2.00	10.50	3.50	8.70
26........	3.10	8.00	16.00	9.40	5.00	20.00	2.50	3.40	2.00	9.00	10.50	6.60
27........	3.00	7.00	13.70	7.50	4.50	16.00	2.80	3.60	2.00	6.00	8.80	5.60
28........	2.80	6.00	11.20	6.40	3.20	18.00	2.90	2.70	2.00	4.20	6.70	5.00
29........	2.70	......	8.70	6.20	2:70	13.80	3.20	2.60	2.00	3.20	4.50	4.60
30........	2.60	......	7.10	6.10	3.00	9.00	3.10	2.10	1.90	2.90	3.70	4.30
31........	2.50	......	6.20	......	2.50	......	10.60	3.20	......	2.70	......	11.00

The following measurements were made by Max Hall and James R. Hall during 1901:

Feb. 12—Gage height, 10.70 feet; discharge, 11,759 second-feet.
March 13—Gage height, 5.55 feet; discharge, 5,644 second-feet.
October 29—Gage height, 1.70 feet; discharge, 1,583 second-feet.

Daily gage height of Tallapoosa River at Milstead, Ala., for 1901.

Day.	Jan.	Feb.	Mar.	Apr	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.......	14.30	7.40	5.30	26.00	5.00	8.70	5.10	2.10	4.00	2.20	1.70	2.00
2.......	15.50	7.20	5.20	22.00	4.80	8.60	4.20	2.20	3.50	2.90	1.70	2.00
3.......	14.50	7.50	5.10	23.00	4.70	9.70	4.30	2.30	2.90	6.10	1.70	1.95
4.......	11.00	24.07	5.00	18.00	4.60	10.90	4.00	2.20	2.70	6.40	1.80	2.20
5.......	9.80	26.00	4.90	14.20	4.40	8.00	3.30	2.10	2.40	5.10	1.95	2.40
6.......	8.70	18.30	4.70	10.80	4.30	[illegible]	3.60	2.10	2.20	4.00	1.95	2.40
7.......	7.40	12.60	4.50	9.60	4.20	12.10	4.00	2.60	2.10	3.20	2.00	2.30
8.......	6.10	10.50	4.40	7.20	4.20	10.10	4.80	2.60	2.00	2.50	1.90	2.20
9.......	5.30	13.10	4.40	6.80	4.10	6.30	4.70	2.30	2.00	2.10	1.90	2.20
10.......	5.00	14.00	4.70	6.20	3.90	5.90	3.70	2.30	1.90	2.00	2.00	2.20
11.......	6.00	12.60	7.70	5.80	3.80	4.50	2.90	2.10	1.90	1.90	1.90	2.30
12.......	24.20	10.90	6.00	5.60	3.80	4.10	2.60	2.30	1.80	1.90	1.80	2.50
13.......	30.50	9.80	5.50	6.10	3.80	4.20	2.60	2.90	1.80	1.90	1.80	2.40
14.......	22.00	8.20	6.00	8.80	4.50	[illegible]	2.10	2.50	2.80	2.00	1.75	2.60
15.......	18.00	7.70	5.50	10.70	4.30	7.30	2.20	2.10	4.20	2.10	1.75	6.00
16.......	11.50	6.90	5.10	8.70	4.00	5.70	2.30	3.20	3.10	2.10	1.80	13.40
17.......	12.20	6.60	4.50	7.70	3.60	6.00	5.30	8.90	3.00	2.00	1.80	9.00
18.......	12.10	6.50	4.10	11.00	3.50	[illegible]	4.80	8.00	5.60	1.90	1.80	6.00
19.......	9.70	6.30	4.00	23.00	3.50	4.40	4.30	6.60	9.10	1.90	1.90	3.90
20.......	8.00	6.20	6.00	22.00	5.50	4.00	3.50	5.90	7.10	1.80	2.10	3.60
21.......	7.10	5.90	7.90	13.40	10.50	[illegible]	3.30	9.60	5.00	1.80	2.20	3.40
22.......	6.80	5.80	6.30	10.70	16.20	3.30	3.10	7.20	3.80	1.70	2:20	3.20
23.......	6.40	5.70	6.20	8.90	14.20	3.30	2.80	20.75	2.70	1.70	2.30	3.10
24.......	6.20	6.00	10.10	7.60	12.00	3.20	3.50	21.00	2.30	1.70	2.20	3.10
25.......	7.00	6.10	8.90	6.90	9.00	9.10	2.40	9.40	2.10	1.70	2.20	3.00
26.......	6.80	6.10	10.20	6.50	10.00	3.10	2.20	5.90	2.10	1.60	2.10	2.90
27.......	6.70	6.00	14.30	6.10	8.40	2.90	2.50	4.20	2.00	1.70	2.30	2.95
28.......	6.70	5.50	17.50	5.80	6.40	2.80	2.50	5.90	2.10	1.70	2.20	3.05
29.......	6.60	......	15.00	5.50	6.00	2.60	2.30	8.70	2.30	1.70	2.10	38.00
30.......	6.80	......	9.90	5.20	5.10	2.60	2.20	7.70	2.50	1.70	2.00	47.00
31.......	7.00	......	31.50	......	4.80	......	2.20	4.70	......	1.70	......	39.00

Rating table for Tallapoosa River at Milstead, Ala., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Ft*	*Feet.*	*Second Ft.*
1.5	1,337	4.1	3,262	18.0	19,900
1.6	1,450	4.2	4,375	19.0	21,025
1.7	1,562	4.3	4,487	20.0	22,150
1.8	1,675	4.4	4,600	21.0	23,275
1.9	1,787	4.5	4,712	22.0	24,400
2.0	1,900	4.6	4,825	23.0	25,525
2.1	2,012	4.7	4,937	24.0	26,650
2.2	2,125	4.8	5,050	25.0	27,775
2.3	2,237	4.9	5,162	26.0	28,900
2.4	2,350	5.0	5,275	27.0	30,025
2.5	2,462	5.5	5,837	28.0	31,150
2.6	2,575	6.0	6,400	29.0	32,275
2.7	2,687	6.5	6,962	30.0	33,400
2.8	2,800	7.0	7,525	31.0	34,525
2.9	2,912	7.5	8,087	32.0	35,650
3.0	3,025	8.0	8,650	33.0	36,775
3.1	3,137	8.5	9,212	34.0	37,900
3.2	3,250	9.0	9,775	35.0	39,025
3.3	3,362	10.0	10,900	36.0	41,150
3.4	3,475	11.0	12,025	37.0	41,275
3.5	3,587	12.0	13,150	38.0	42,400
3.6	3,700	13.0	14,275	39.0	43,525
3.7	3,812	14.0	15,400	40.0	44,650
3.8	3,925	15.0	16,525	41.0	45,775
3.9	4,037	16.0	17,650	42.0	46,900
4.0	4,150	17.0	18,775	43.0	48,025

NOTE—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

**Estimated monthly discharge of Tallapoosa River at Milstead, Ala.*

[Drainage area, 3,840 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1897.						
August, 7-31	12,440	1,070	3,173	157,340	0.77	0.83
September	1,467	420	742	44,155	0.21	0.19
October	470	380	424	26,070	0.12	0.11
November	1,200	470	729	43,379	0.21	0.19
December	6,604	1,070	2,214	136,135	0.67	0.58
1898.						
January	4,105	1,575	2,426	149,170	0.72	0.63
February	2,265	1,690	1,912	106,187	0.52	0.50
March	5,715	1,575	2,313	142,222	0.69	0.60
April	21,240	2,150	5,748	342,029	1.67	1.50
May	2,610	885	1,493	91,802	0.45	0.39
June	3,070	540	1,314	78,188	0.38	0.34
July	5,485	885	2,493	153,290	0.75	0.65
August	25,610	1,920	7,418	456,118	2.22	1.93
September	6,520	1,345	2,637	156,912	0.77	0.69
October	36,420	1,115	7,280	447,633	2.19	1.90
November	16,180	2,035	6,049	359,940	1.76	1.58
December	11,120	3,530	5,741	353,003	1.73	1.50
1899.						
January	22,197	4,116	8,417	517,541	2.53	2.19
February	44,952	6,945	15,688	871,267	4.26	4.09
March	32,652	7,314	12,399	762,385	3.72	3.23
April	21,582	5,100	9,016	536,489	2.62	2.35
May	4,731	2,517	3,351	206,045	1.00	0.87
June	2,999	1,287	2,040	121,388	0.59	0.53
July	20,290	795	4,985	306,516	1.50	1.30
August	4,362	1,287	2,222	136,625	0.67	0.58
September	2,394	430	984	58,552	0.29	0.26
October	1,656	320	1,014	62,348	0.30	0.26
November	7,068	918	1,787	106,334	0.53	0.47
December	18,138	1,656	4,728	290,713	1.42	1.23
1900.						
January	10,335	2,125	3,728	229,226	1.12	0.97
February	48,305	2,237	12,950	719,206	3.50	3.37
March	17,650	5,723	10,208	627,665	3.07	2.66
April	18,775	4,712	9,016	536,489	2.62	2.35
May	6,736	2,462	3,718	228,611	1.12	0.97
June	27,831	2,575	8,317	494,896	2.42	2.17
July	11,572	2,462	5,405	332,340	1.63	1.41
August	6,960	1,675	2,814	173,026	0.84	0.73
September	28,447	1,337	4,975	296,033	1.45	1.30
October	13,262	1,337	3,787	232,854	1.14	0.99
November	11,460	2,462	4,224	251,345	1.23	1.10
December	18,775	2,800	6,475	398,132	1.95	1.69
The year	48,305	1,337	6,301	4,519,823	22.09	1.64

*See explanation page 13.

Estimated monthly discharge of Tallapoosa River near Milstead, Ala.

[Drainage area, 3,840 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1901.					
January	33,962	5,275	11,476	3.45	2.99
February	28,900	5,837	10,440	2.83	2.72
March	35,087	4,150	8,374	2.52	2.18
April	28,900	5,499	12,020	3.49	3.13
May	17,875	3,587	6,440	1.94	1.68
June	13,262	2,775	5,976	1.74	1.56
July	5,387	2,012	3,398	1.01	.88
August	23,275	2,012	5,904	1.78	1.54
September	9,887	1,675	3,137	.91	.82
October	6,849	1,562	2,364	.71	.62
November	2,237	1,562	1,855	.54	.48
December	*70,000	1,843	8,282	2.49	2.16
The year	*70,000	1,562	6,639	23.41	1.73

*Approximate.

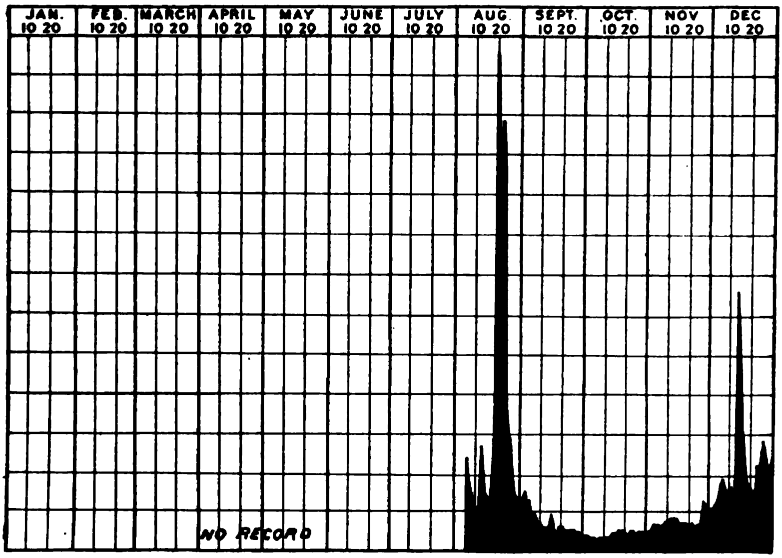

Fig. 1—Discharge of Tallapoosa River at Milstead, Ala., 1897.

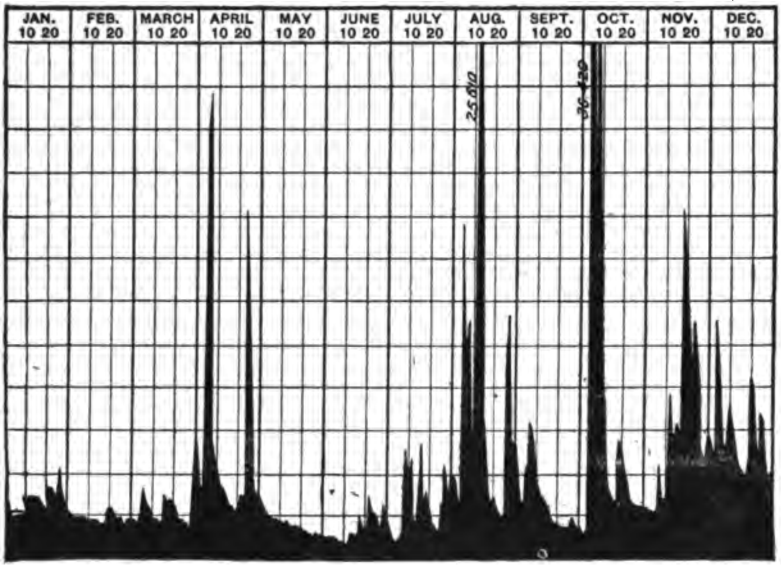

Fig. 2—Discharge of Tallapoosa River at Milstead, Ala., 1898.

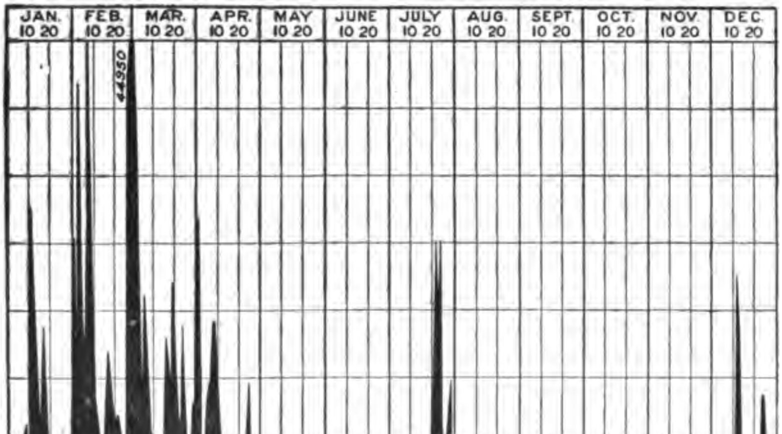

Fig. 3—Discharge of Tallapoosa River at Milstead, Ala., 1899.

The amount of water delivered from the drainage basin as measured at the points named below has been computed in terms of depth in inches. The normals given are the monthly averages for times during which measurements or computations were had. The figures for the yearly normal are the sums of these monthly averages.

Depth of run-off in inches from the drainage basin of Tallapoosa River at Milstead, Ala.

Day.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Normal ...	1.96	2.78	2.50	2.60	1.13	1.28	1.22	1.38	.86	1.09	1.02	1.90	19.70
1898	.72	.52	.69	1.67	.45	.38	.75	2.22	.77	2.19	1.76	1.73	13.85
1899	2.53	4.26	3.72	2.62	1.00	.59	1.50	.67	.29	.30	.53	1.42	19.43
1900	1.12	3.50	3.07	2.62	1.12	2.42	1.63	.84	1.45	1.14	1.23	1.95	22.09
1901	3.45	2.83	2.52	3.49	1.94	1.74	1.01	1.78	.91	.71	.54	2.49	23.41

Minimum monthly discharge of Tallapoosa River at Milstead, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.

	1899			1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January ...	4,116	374	1	2,125	193	4	5,275	480	1
February .	6,945	631	1	2,237	203	1	5,837	531	1
March	7,314	665	1	5,725	520	2	4,150	377	1
April	5,100	464	1	4,712	428	1	5,500	500	1
May	2,517	229	3	2,462	224	1	3,587	326	2
June	1,287	117	4	2,575	234	1	2,575	234	2
July	795	72	1	2,462	224	2	2,012	183	1
August ...	1,287	117	3	1,675	152	1	2,012	183	5
September	430	39	3	1,337	122	2	1,675	152	2
October ...	320	29	2	1,337	122	1	1,562	142	10
November .	918	83	5	2,462	244	9	1,562	142	3
December .	1,656	151	1	2,800	255	3	1,843	168	1

NOTE—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "net H. P. per foot of fall" in this table for that month.

2. TALLAPOOSA RIVER NEAR SUSANNA, ALABAMA.

This station was established July 27, 1900, by J. R. Hall. It is located at the mouth of Blue Creek, which is 10 feet above the east landing of McCarty's ferry, 13 miles southwest of Dadeville, and 3 miles from Susanna, the nearest postoffice. The rod is graduated to feet and tenths; it is 18 feet long, and is nailed vertically to a tree overhanging the water on the south side of the creek at the junction of the creek and the river. The gage is referred to a bench mark on a white hickory tree about 40 feet from the rod on the south bank of the creek, and is 376.67 feet above tide water. Discharge measurements are made from a boat held in place by a wire stretched across the river, upon which the distances from the initial point are tagged. The section is an exceptionally good one, depth and current being almost uniform the entire width of the stream. The observer is T. A. Walls, a farmer who lives 1 mile from the station. During 1900 and 1901 the following discharge measurements were made by James R. Hall:

1900:

July 27—Gage height, 1.80 feet; discharge, 2,309 second-feet.
August 9—Gage height, 1.55 feet; discharge, 1,900 second-feet.
September 28—Gage height, 1.50 feet; discharge, 1,809 second-feet.
November 24—Gage height, 2.40 feet; discharge, 3,629 second-feet.

1901:

July 9—Gage height, 2.80 feet; discharge, 5,628 second-feet.
Feb. 27.—Gage height, 2.90 feet; discharge, 5,135 second-feet.
NOTE—The gage was washed away, and this station was discontinued on March 30th, 1901.

Daily gage height, in feet, of Tallapoosa River, near Susanna, Ala., for 1900.

Day.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	5.80	2.40	1.40	1.80	2.00	17	......	1.95	8.40	2.35	1.75	2.60
2	......	4.00	3.80	1.40	1.70	2.00	18	......	1.95	4.80	2.30	1.75	2.50
3	......	2.00	4.80	1.40	1.70	2.10	19	......	1.80	3.00	2.20	1.80	2.40
4	......	1.80	4.20	1.35	1.65	2.20	20	......	1.75	2.50	2.10	1.85	4.50
5	......	1.80	2.25	1.30	1.65	2.30	21	......	1.70	1.80	1.90	1.85	5.80
6	......	2.10	1.50	2.80	1.65	2.50	22	......	1.70	1.80	1.70	1.90	4.50
7	......	2.20	1.45	3.00	1.60	2.40	23	......	1.90	1.80	3.90	2.40	4.00
8	......	1.70	1.45	2.50	1.60	2.40	24	......	2.00	1.70	6.00	2.40	4.00
9	......	1.55	1.40	1.85	1.60	2.40	25	......	2.05	1.60	5.00	3.00	3.70
10	......	1.50	1.35	1.80	1.60	2.30	26	......	2.50	1.50	4.30	4.90	3.20
11	......	1.40	1.35	1.75	1.60	2.10	27	1.80	2.15	1.50	4.10	4.20	2.80
12	......	1.40	1.35	1.70	1.55	2.00	28	1.90	2.00	1.50	2.30	3.90	2.70
13	......	1.40	1.35	1.90	1.55	1.90	29	1.80	1.90	1.45	2.20	3.00	2.60
14	......	1.40	1.30	2.40	1.60	3.90	30	4.00	1.80	1.45	1.90	2.80	2.70
15	......	1.40	1.35	2.45	1.60	3.90	31	.680	2.25	.....	1.85	.....	2.90
16	......	1.90	11.70	2.40	1.60	2.80							

Daily gage height of Tallapoosa River at Susanna, Ala., for 1901.

Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.	Day.	Jan.	Feb.	Mar.
1........	6.0	3.40	2.70	12........	13.5	4.00	3.10	23........	3.0	2.80	2.70
2........	6.0	3.45	2.60	13........	11.5	3.50	2.90	24........	3.1	2.90	3.30
3........	5.1	3.30	2.65	14........	8.0	3.04	2.60	25........	3.4	3.00	3.40
4........	4.5	11.50	2.70	15........	6.1	3.30	2.50	26........	3.1	3.00	3.60
5........	3.9	9.50	2.65	16........	4.5	3.20	2.40	27........	3.2	2.90	7.40
6........	3.5	6.50	2.60	17........	5.0	3.10	2.40	28........	3.1	2.80	6.90
7........	3.2	4.40	2.50	18........	4.5	3.10	2.40	29........	3.0	......	6.10
8........	3.0	4.30	2.40	19........	3.9	3.05	2.45	30........	3.2	......	4.10
9........	2.9	4.80	2.50	20........	3.4	3.00	3.00	31........	3.3	......	.....
10........	2.8	4.90	2.70	21........	3.2	2.90	3.40				
11........	3.4	4.50	3.30	22........	3.1	2.85	2.90				

Rating table for Tallapoosa River, at Susanna, Ala., 1900 and *1901.*

Gage Height.	Discharge.	Gage Height.	Discharge.
1.0	.....	4.0	11,030
1.2	.....	4.2	11,930
1.4	1,680	4.4	12,830
1.6	1,960	4.6	13,730
1.8	2,320	4.8	14,630
2.0	2,740	5.0	15,530
2.2	3,230	5.5	17,780
2.4	3,850	6.0	20,030
2.6	4,730	6.5	22,280
2.8	5,630	7.0	24,530
3.0	6,530	8.0	29,030
3.2	7,430	9.0	33,530
3.4	8,330	10.0	38,030
3.6	9,230	11.0	42,530
3.8	10,130	11.7	45,680

NOTE—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Tallapoosa River, near Susanna, Alabama.

[Drainage area, 2,610 square miles.]

Month	Discharge in second-feet.				Run-off.	
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Depth in inches.	Second feet per square mile.
1900.						
July 27 to 31.........	......	......	8,364	....	......	......
August	19,130	1,680	3,258	200,327	1.44	1.25
September	45,680	1,570	6,083	361,964	2.60	2.33
October	20,030	1,570	4,776	293,665	2.11	1.83
November	15,080	1,885	3,676	218,737	1.57	1.41
December	19,130	2,520	6,288	386,634	2.78	2.41

Estimated monthly discharge of Tallapoosa River, near Susanna, Alabama.
[Drainage area, 2,610 square miles.]

Month.	Discharge in second-feet			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1901.					
January	53,780	5,630	13,265	5.86	5.08
February	44,780	5,630	11,303	4.51	4.33
March	26,330	3,850	7,546	3.31	2.89

Minimum monthly discharge of Tallapoosa River at Susanna, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.
[Drainage area, 2,610 square miles.]

	1900				1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.		Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
July	2,320	211	2	January	5,630	512	1
August	1,680	153	5	February	5,630	512	2
September	1,570	143	1	March	3,850	350	4
October	1,570	143	1				
November	1,885	171	2				
December	2,520	229	1				

NOTE—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "net H. P. per foot of fall" in this table for that month.

3. TALLAPOOSA RIVER, NEAR STURDEVANT, ALABAMA.

This station was established July 19, 1900, by J. R. Hall. It is located at the bridge, Columbus & Western Division of the Central of Georgia Railroad, a fourth of a mile west of Sturdevant. The gage rod is 20 feet high, and is graduated to feet and tenths. It is in two sections, and is fastened verti-

cally, the shorter section to a post at the edge of the waer on the east bank, about 20 feet below the bridge, and the longer section to the first stone pier from the east bank. It is so set that when the water rises above the short section it is on the long section, and the readings are made as from one continuous rod. The initial point of sounding is the east end of the bridge. The section is broken by three piers and by some large rocks below the bridge. The gage is referred to a bench mark consisting of a nail in the southwest corner of pier No. 2, east side of the river, 455.70 feet above tide water, and 14.20 feet above the zero of the gage. The observer is B. F. Neighbors, farmer and postmaster at Sturdevant, who lives a fourth of a mile from the station. During 1900 the following discharge measurements were made by James R. Hall:

July 20—Gage height, 2.85 feet; discharge, 2,603 second-feet.
August 13—Gage height, 1.95 feet; discharge, 1,887 second-feet.

Daily gage height, in feet, of Tallapoosa River near Sturdevant, Ala. for 1900.

Day.	July	Aug	Sept	Oct	Nov	Dec	Day.	July	Aug	Sept	Oct	Nov	Dec
1	.....	4.30	3.40	1.80	2.50	2.90	17	.....	3.00	7.00	2.60	2.30	3.20
2	.....	3.40	6.10	1.70	3.40	2.80	18	.....	2.80	5.00	2.20	2.20	3.10
3	.....	2.80	4.20	1.60	4.70	2.70	19	2.95	4.00	3.80	2.10	2.20	3.00
4	.....	2.50	2.90	1.60	3.60	3.00	20	2.80	2.90	3.00	2.00	2.20	5.20
5	.....	2.40	2.50	3.30	3.30	3.20	21	3.05	2.40	2.70	1.90	2.50	6.80
6	.....	2.35	2.20	3.00	3.20	3.30	22	2.75	2.30	2.50	2.10	3.20	5.30
7	.....	2.25	2.00	3.00	2.90	3.20	23	2.65	2.40	2.40	5.00	3.50	4.90
8	.....	2.20	1.90	2.90	2.70	3.00	24	2.55	2.70	2.30	7.30	3.20	5.60
9	.....	2.10	1.80	3.10	2.60	2.80	25	2.65	2.50	2.20	6.40	4.80	4.70
10	.....	2.00	1.70	3.20	2.50	2.70	26	2.60	2.80	2.10	5.40	5.90	4.20
11	.....	1.95	1.60	3.30	2.40	2.60	27	2.50	2.60	2.00	4.20	5.40	3.90
12	.....	1.90	1.60	3.40	2.40	2.60	28	2.70	2.60	2.00	3.60	3.40	3.60
13	.....	2.00	1.60	3.50	2.40	2.70	29	6.50	2.40	2.00	2.90	3.20	3.40
14	.....	2.10	1.80	3.50	2.30	4.70	30	7.60	2.30	1.90	2.70	3.10	3.50
15	.....	2.60	8.80	3.00	2.30	3.00	31	5.00	2.80	.....	2.60	.....	7.50
16	.....	3.40	12.00	2.60	2.30	3.70							

During the year 1901 James R. Hall made one measurement, as follows:

March 8—Gage height, 3.40 feet; discharge, 3,774 second-feet.

During the year 1902 the following discharge measurements have been made at Sturdevant by W. E. Hall:

July 11—Gage height, 1.85 feet; discharge, 1,440 second-feet.
September 17—Gage height, 0.80 feet; discharge, 658 second-feet.
October 9—Gage height. 1.08 feet; discharge, 858 second-feet.
November 12—Gage height, 1.34 feet; discharge, 1,000 second-feet.

Daily gage height of Tallapoosa River at Sturdevant, Ala., for 1901.

Day.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
1........	7.0	4.6	3.8	7.4	3.8	5.5	4.0	3.1	3.2	2.4	1.6	1.7
2........	6.8	4.5	3.8	6.8	3.7	5.5	3.5	2.8	2.9	4.5	1.6	1.7
3........	6.0	5.8	3.7	8.3	3.7	5.3	3.2	2.5	2.7	6.0	1.6	2.1
4........	5.4	12.9	3.7	7.4	3.6	5.2	3.0	2.3	2.6	3.4	1.6	2.2
5........	4.9	9.4	3.6	5.7	3.5	4.8	2.9	2.3	2.4	2.7	1.7	2.3
6........	5.2	7.7	3.6	5.0	3.5	4.6	2.8	2.2	2.3	2.3	1.8	2.2
7........	5.1	6.5	3.5	4.7	3.4	5.6	4.3	2.1	2.2	2.1	1.8	2.1
8........	4.0	5.4	3.4	4.4	3.4	4.9	4.0	2.4	2.1	2.0	1.8	2.1
9........	4.0	5.7	3.4	4.2	3.3	3.8	3.4	2.2	2.0	2.0	1.8	2.2
10........	4.1	5.4	3.9	4.0	3.3	3.6	3.0	2.0	2.0	2.0	1.8	2.2
11........	6.0	5.2	4.3	3.9	3.3	3.4	2.6	2.2	2.0	1.9	1.7	2.3
12........	14.1	5.1	4.0	3.9	3.2	3.3	2.3	2.4	2.0	1.9	1.7	2.2
13........	11.0	4.8	3.8	4.1	3.2	3.2	2.2	2.3	2.0	2.1	1.7	2.1
14........	9.2	4.6	3.6	6.0	3.4	4.9	2.1	2.2	4.0	2.1	1.8	3.0
15........	6.1	4.4	3.4	6.4	3.3	4.4	2.1	2.0	3.4	2.0	1.8	7.8
16........	5.3	4.3	3.3	5.3	4.2	4.1	2.0	5.3	2.8	2.0	1.8	5.9
17........	5.7	4.2	3.3	4.7	3.1	3.8	2.2	7.2	3.6	1.9	1.8	4.1
18........	5.3	4.2	3.2	4.4	3.0	3.6	3.8	5.9	7.0	1.9	1.8	3.5
19........	4.0	4.1	3.2	8.5	3.0	3.3	3.6	5.3	5.2	1.8	2.0	3.0
20........	4.4	4.1	3.6	9.0	3.3	3.1	3.2	6.6	4.3	1.8	2.2	2.8
21........	4.3	4.0	4.3	6.7	6.1	3.0	3.0	5.8	3.4	1.7	2.2	2.6
22........	4.2	4.0	3.9	5.2	7.6	2.9	2.8	5.6	3.0	1.7	2.3	2.5
23........	4.1	4.0	3.7	4.8	7.0	2.8	2.4	11.7	2.4	1.7	2.2	2.5
24........	4.2	4.0	4.5	4.6	6.5	2.7	2.2	8.3	2.3	1.7	2.2	3.0
25........	4.3	4.0	4.3	4.4	5.3	2.7	2.1	5.2	2.2	1.7	2.1	2.8
26........	4.2	4.0	5.4	4.3	6.8	2.6	2.1	4.0	2.1	1.7	2.1	2.7
27........	4.1	3.9	8.7	4.2	4.5	2.6	2.1	3.3	2.0	1.6	2.0	2.6
28........	4.3	3.9	8.2	4.1	4.4	2.5	2.1	4.4	2.0	1.6	1.9	2.8
29........	4.5	......	7.5	4.0	4.3	2.5	2.0	5.2	2.2	1.6	1.8	15.7
30........	4.5	......	5.0	3.9	4.2	5.2	2.1	4.3	2.3	1.6	1.8	17.2
31........	4.6	......	8.9	......	4.0	......	2.8	3.5	......	1.6	......	12.0

4. SURVEY OF TALLAPOOSA RIVER IN ALABAMA.

This survey of a part of Tallapoosa River in Alabama was made in June and July, 1900, under supervision of B. M. Hall, resident Hydrographer, by Field Engineer James R. Hall, levelman and topographer.

The survey began at the Hydrographic Station on the Tallapoosa River, at Milstead, Ala., and ran up the river 64 miles to head of shoal above Griffn's Ferry. The elevations are sea-level elevations.

DESCRIPTION OF RIVER.

The entire river above Milstead runs on granite bed-rock, and has numerous bluffs along its banks, forming excellent sites for dams.

There are two large developed water powers on the river: The Tallassee Falls plant, and the Montgomery Power Company's plant, both of which are near the lower end of the survey. (*See Plates B and C, opposite.*)

PLATE B. Tallassee Falls on Tallapoosa River.

Plate C. Power House and Dam, Montgomery Power Company, on Tallapoosa River, near Tallassee, Ala.

The Tallassee Falls dam and canal, which are six miles above Milstead, utilize a fall of 64 feet, with the whole river. This power and its large cotton manufacturing plant recently completed, is described in the Twentieth Annual Report, U. S. Geological Survey, Part IV, Pages 192-193. This power was capable of realizing 8,900 net H. P. without storage during low water of October, 1901. A break which occurred in the dam on December 29, 1901, has decreased the present available head, but does not stop the machinery.

The Montgomery Power Company dam has a 40-foot dam, nine and a half miles above Milstead. It backs the water six and a half miles up the river, and forms an immense storage basin. This being almost completed in December, 1901, was partly washed out by a great flood December 29, 1901. The water wheels, dynamos, pole line and wiring to Montgomery are all installed, and ready for work as soon as the dam is repaired. The distance to Montgomery is about 27 miles.

With river at stage of lowest water during October, 1901, this plant will develop at the wheels 5.572 net H. P. from the run of the river without drawing on the storage.

The equalizing storage of this dam will add fully 25 per cent. to this power and to the power at Tallassee for continuous running without materially lowering the head at either plant.

The following list of distances and elevations of water and bench marks shows the fall of the river from point to point. The total fall in 56 of the 64 miles surveyed is 364 feet.

Elevations and bench marks along Tallapoosa River from Milstead, Ala., to Griffin Shoals.

Distance from Milstead.	Description or location.	Bench mark elevation above sea level.	Elevation above sea level.
6.0	River surface of tailwater at Tallassee mills	....	206.3
6.2	Water above crest of Tallasee dam	....	269.9
8.5	Upper end of Tallassee Pond	....	269.9
9.5	River below Montgomery Power Company's dam	....	295.25
9.5	Crest of Montgomery Power Company's dam	....	335.25
15.7	Upper end of Montgomery Power Co.'s Pond	....	335.25
16.5	Water at Double Bridge Ferry	....	351.46
16.8	Water at mouth of Wind Creek	....	352.45
16.8	Bench mark' No. 7, bunch of mulberry trees at the mouth of Wind Creek	357.85	....
17.8	Bench mark, No. 22, crooked willow on small branch at north end of Taylor's field	363.30	....
17.8	Water at bench mark No. 22	....	356.18
18.5	Water opposite mouth of Kowaliga Creek	....	357.16
18.75	Bench mark No. 33, mulberry 100 feet above old Baker field	371.73	....
18.75	Water at bench mark No. 33	....	359.75
19.4	Bench mark No. 42, willow at Garnetts Ford	364.60	....
19.4	Water at Garnetts Ford	....	360.55
19.7	Bench mark No. 46, pine at mouth of High Falls Branch	373.98	....
19.7	Water at "blue hole" at mouth of High Falls Branch	....	362.40
20.1	Water at "blue hole" at foot of Long Branch shoals	....	362.40
21.0	Bench mark No. 62, mulberry, 300 yards above mouth of Long Branch	382.45	....
21.0	Water at bench mark No. 62, top of Long branch shoals	....	367.23
21.3	Bench mark No. 70, white hickory at McCarty's Ferry, mouth of Blue Creek	376.67	....
21.3	Water at McCarty's Ferry, mouth of Blue Creek	....	367.80
23.0	Top of shoal opposite mouth of Peru Branch	....	372.55
23.8	Water at mouth of Gold Mine Branch	....	375.17
23.8	Bench mark No. 100, mulberry at mouth of Gold Mine Branch	386.00	....
24.4	Bench mark No. 110, water oak at Robinson's Ferry	404.40	....
24.4	Water at Robinson's Ferry	....	380.20
25.6	Water at top of Upper Robinson Shoals	....	389.10
25.6	Bench mark No. 124, small sycamore at mouth of small branch	395.10	....
27.7	Water at mouth of small branch in Pace's field	....	390.90
28.7	Bench mark No. 140, watr oak at foot of Hardy Shoals, in Pace's field	414.30	....
29.5	Bench mark No. 150, dead stump 100 feet below the mouth of Big Sandy Creek	398.08	....
29.5	Water at mouth of Big Sandy Creek	....	
30.0	Bench mark No. 165, big red oak at Young's Ferry	413.50	....
30.0	Water at Young's Ferry	....	394.00
31.0	Water at Cherokee Bluff	....	394.60
31.2	Bench mark No. 175, big walnut 200 yards above Monowa Creek	416.75	....
34.0	Bench mark No. 180, 16-inch pine tree at third bar of Seago Shoals	424.72	....
34.0	Water at third bar of Seago Shoals, opposite bench mark No. 180	....	399.92
35.8	Bench mark No. 190, large white oak at east landing at Walkers Ferry	436.90	....
35.8	Water at Walkers Ferry	....	429.65
37.0	Bench mark No. 210, leaning white oak at mouth of small branch at upper end of Upshaw place	438.60	....
37.4	Water at bench mark No. 210	....	432.00
37.6	Water at top of fish trap	....	436.47
38.3	Bench mark No. 215, 16-inch white oak on small branch at upper end of Locke's old field	448.90	....

Distance from Milstead.	Description or location.	Bench mark elevation above sea level.	Elevation above sea level.
38.3	Water at bench mark No. 215	....	438.00
39.3	Water under Central railroad bridge at Sturdevant, Alabama	....	444.25
39.3	Bench mark on top of rail over first pier of the east end of Central Railroad bridge	505.90	....
41.2	Bench mark No. 2?0. large water oak at east landing of Dennis Ferry	457.15	....
41.2	Water at Dennis Ferry	....	445.85
42.2	Water at mouth of branch on left bank of river	....	448.20
45.3	Water 600 feet below mouth of Hillabee Creek	....	472.60
48.3	Bench mark No. 310, water oak at east landing of Welch's Ferry	504.15	....
48.3	Water at Welch's Ferry	....	492.30
50.0	Bench mark No. 330, beech 150 feet above mouth of Freeman's Branch	526.62	....
50.0	Water 150 feet above mouth of Freeman's Branch	....	521.04
52.0	Water at Whaleys Ferry	....	529.48
52.0	Bench mark No. 340, birch at Whaleys Ferry	539.38	....
55.4	Bench mark No. 350, 10-inch birch at Millers Ferry	552.16	....
55.4	Water at Millers Ferry	....	544.00
60.8	Water at Griffins Ferry	....	557.10
60.8	Bench mark No. 380, double ash tree on left bank at Griffins Ferry	564.76	....
62.0	Bench mark No. 390, 12-inch birch at head of Griffins Shoals	578.87	....
62.0	Water at head of Griffins Shoals	....	570.30

Surveys have been made for a large dam, 35 or 40 feet in height, at or near Double Bridge Ferry, to back the water beyond Robinson's Ferry, a distance of about 8 miles up the river. There is an excellent site for a dam, and the project is entirely feasible. The horse power in proportion to head would be the same as that available at the Montgomery Power Company's dam.

From the mouth of Big Sandy Creek to a point one mile above Griffin's Ferry, a distance of 32 miles, the fall of the Tallapoosa River is 176.5 feet. Nearly all of this fall can be utilized for power by developments similar to those which have been made, and proposed below. A study of the profile and of the above table of distances and elevations will give the distribution of the fall, showing the distance to which dams of certain height will back the water, at the various shoals, but the question of the best power sites, and the proper plan of development, height and location of dams, etc., for any point will depend on the special conditions favorable or unfavorable for dams and canals, the width of river bed, or flooded areas above, and the value of farming lands which

may be flooded. All of which can be determined only by special investigation and surveys. It will be safe, however, to assume that a practicable site for a dam 40 feet high or under, can be found in the vicinity of any location which may be selected, and the power obtainable can be estimated by using the volume of water, or its equivalent net horse power per foot of fall, and the proposed head to be developed.

The water supply or discharge of Tallapoosa River at different points may be closely approximated from the foregoing records of Milstead, Susanna, and Sturdevant Hydrographic Stations, and also at Dadeville, and Alexander City stations, on the tributaries.

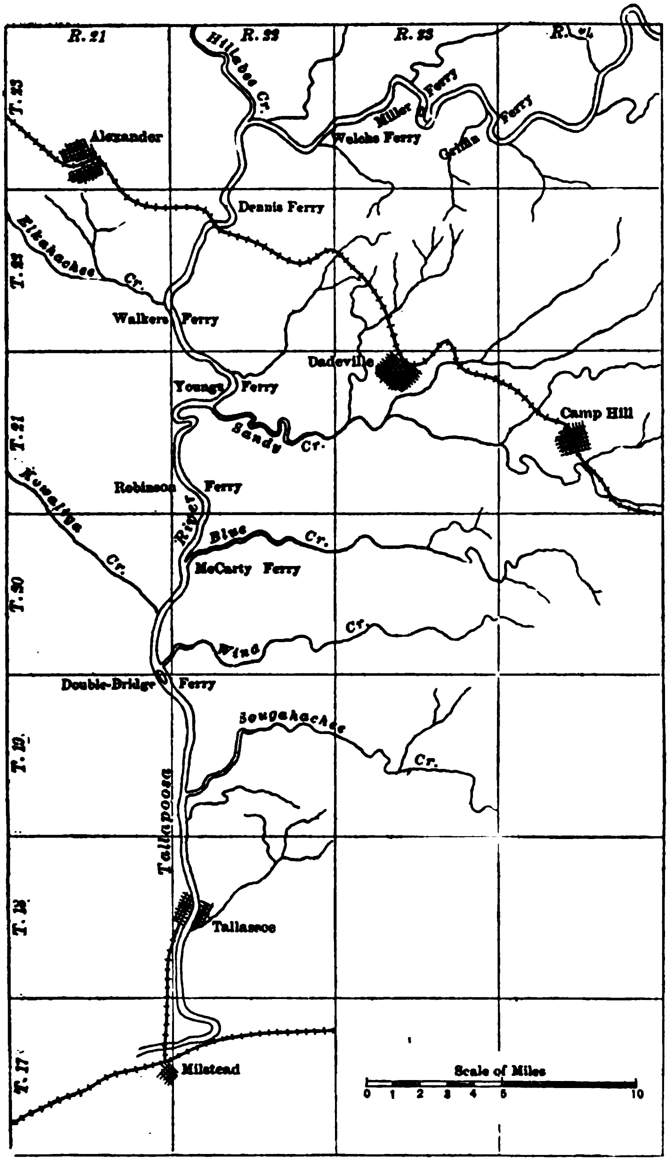

Fig. 4—Map of Tallapoosa River from top of Griffin Shoals, Ala., to Milstead, Ala.

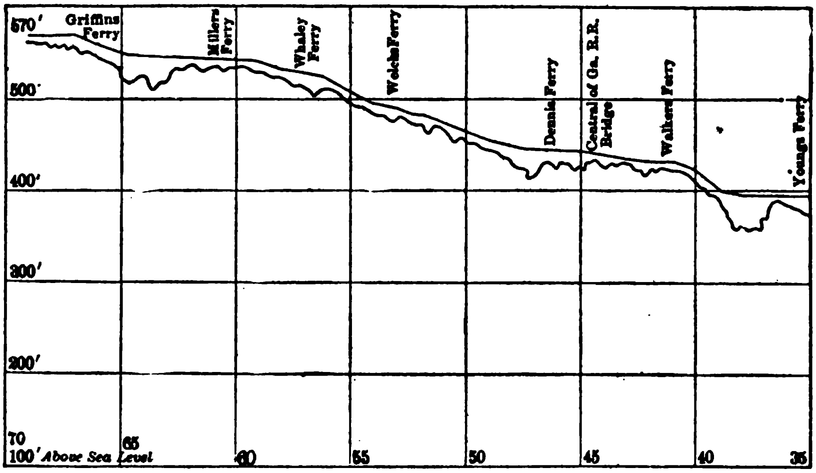

Fig. 5—Profile of Tallapoosa River from top of Griffin Shoals, Ala., to Milstead, Ala.

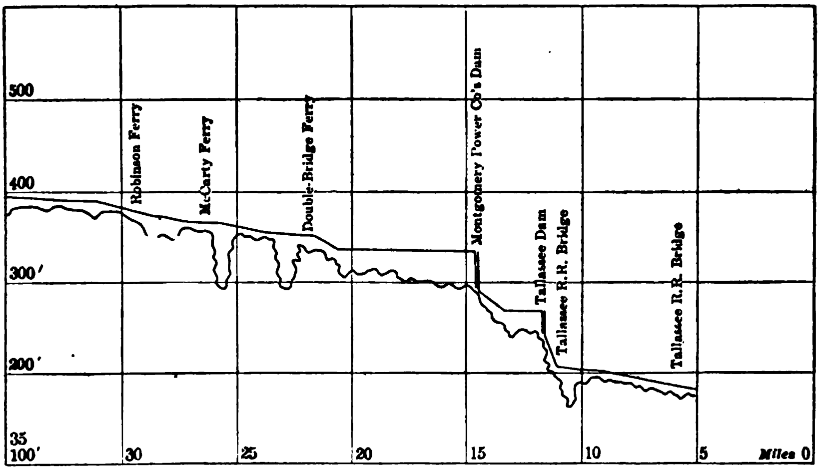

Fig. 6—Profile of Tallapoosa River from top of Griffin Shoals, Ala., to Milstead, Ala.—*Continued.*

5. BIG SANDY CREEK, NEAR DADEVILLE, ALABAMA.

This station, which was established by J. R. Hall, August 2, 1900, is located about 4½ miles southwest of Dadeville, at the highway bridge on the Dadeville-Susanna road. The gage, which is graduated to feet and tenths, is 16 feet high, and is fastened vertically to the first pier on the north side of the creek. The initial point of sounding is at the gage rod. The section is good for ordinary or flood measurements, but is rather wide and shoaly for low-water measurements. The latter can, however, be made a short distance from the gage. The observer is T. H. Finch, Dadeville, Alabama. During 1900 the following measurements were made by James R. Hall:

July 6—Gage height, 1.20 feet; discharge, 260 second-feet.
August 8—Gage height, 1.00 foot; discharge, 110 second feet.
August 8—Gage height, 1.00 foot; discharge, 116 second-feet.
August 25—Gage height, 1.35 feet; discharge, 281 second-feet.
Nov. 16—Gage height, 1.10 feet; discharge, 155 second-feet.
Dec. 31—Gage height, 2.00; discharge, 870 second-feet.

The measurements of August 8 and November 16 were made a half mile below Smith's bridge.

Daily gage height, in feet, of Big Sandy Creek near Dadeville, Ala., for 1900.

Day.	Aug.	Sept.	Oct.	Nov.	Dec	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.00	1.10	0.95	1.00	1.10	17	1.80	3.90	1.10	1.05	1.45
2	1.20	1.10	.90	1.30	1.15	18	1.20	1.50	1.00	1.10	1.30
3	1.10	1.40	.90	2.00	1.25	19	1.10	1.10	1.05	1.10	2.40
4	1.10	1.30	.90	1.80	1.40	20	1.00	1.05	1.05	1.10	4.50
5	1.10	1.20	3.50	1.40	1.35	21	1.00	1.00	1.00	1.10	3.50
6	1.05	1.05	1.80	1.20	1.30	22	.90	1.00	1.50	1.30	1.70
7	1.05	1.00	1.25	1.20	1.25	23	.90	1.00	1.45	1.25	1.50
8	1.00	1.00	1.20	1.20	1.20	24	1.70	1.00	1.40	1.20	1.40
9	1.05	.95	1,10	1.15	1.15	25	1.40	1.00	1.20	1.50	1.40
10	1.00	2.00	1.15	1.15	1.10	26	1.60	1.00	1.15	1.90	1.35
11	1.00	1.80	1.10	1.15	1.10	27	1.15	1.05	1.10	1.80	1.35
12	9.05	1.40	1.20	1.15	1.10	28	1.10	1.05	1.05	1.20	1.35
13	9.00	1.20	1.30	1.10	1.10	29	1.00	1.00	1.05	1.15	1.30
14	9.00	1.20	1.15	1.10	2.20	30	1.00	.90	1.00	1.10	1.75
15	1.80	2.00	1.10	1.10	1.80	31	1.80	......	1.05	......	2.00
16	1.00	2.20	1.05	1.10	1.45						

Daily gage height, in feet, of Big Sandy Creek near Dadeville, Ala., for 1901.

Day.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec
1	1.90	1.35	1.40	4.40	1.40	1.40	1.30	1.10	1.30	4.20	.85	.90
2	1.90	1.35	1.40	7.40	1.40	1.40	1.25	1.10	1.30	4.00	.85	.90
3	1.95	3.10	1.35	2.70	1.45	4.00	1.20	1.00	1.20	3.00	.85	1.40
4	1.70	6.00	1.35	2.00	1.35	5.60	1.20	1.05	1.10	3.50	.85	1.40
5	1.60	1.90	1.35	1.80	1.35	1.90	1.40	1.10	1.10	2.00	.85	1.40
6	1.50	1.75	1.40	1.60	1.35	3.50	1.50	1.05	1.10	1.80	.90	1.30
7	1.45	1.55	1.35	1.50	1.40	2.40	1.40	1.30	1.00	1.80	.90	1.10
8	1.40	2.10	1.35	1.50	1.35	1.90	1.25	1.20	1.00	1.50	1.00	1.00
9	1.40	3.50	1.40	1.50	1.35	1.50	1.20	1.10	1.00	1.40	1.00	1.10
10	1.40	2.20	1.45	1.50	1.30	1.60	1.20	1.10	.90	1.20	1.00	1.00
11	1.90	2.00	1.40	1.50	1.30	1.70	1.10	1.10	.90	1.20	1.00	1.00
12	1.70	1.70	1.35	1.55	1.35	2.00	1.10	1.20	.85	1.00	.90	1.00
13	2.50	1.50	1.35	1.65	1.35	1.80	1.10	1.15	.80	1.90	1.00	1.10
14	1.90	1.50	1.35	1.65	1.50	1.90	1.10	1.10	1.40	1.90	1.00	4.40
15	1.60	1.50	1.30	1.60	1.50	1.15	1.80	1.00	1.40	1.80	1.00	3.80
16	1.55	1.45	1.30	1.50	1.45	1.70	1.50	5.00	1.80	1.80	1.00	3.00
17	2.00	1.45	1.30	1.50	1.25	1.50	1.50	1.80	2.00	1.70	1.00	2.90
18	2.00	1.45	1.35	1.45	1.40	1.50	1.50	1.80	1.80	1.70	.90	2.50
19	1.60	1.50	1.35	6.00	1.40	1.45	1.30	1.40	1.80	1.70	.90	2.40
20	1.50	1.50	1.80	2.50	1.70	1.45	1.20	1.30	1.70	1.70	.80	2.40
21	1.50	1.45	1.60	2.40	7.00	1.40	1.15	1.20	1.40	1.60	.80	2.00
22	1.45	1.40	1.40	2.10	3.40	1.35	1.15	4.50	1.30	1.60	1.00	2.00
23	1.45	1.40	1.40	1.80	1.80	1.40	1.15	1.50	1.30	1.00	1.00	1.90
24	1.45	1.50	2.20	1.80	1.70	1.40	1.10	1.50	1.20	1.00	.85	1.80
25	1.50	1.50	2.10	1.70	1.50	1.35	1.10	1.40	1.20	.90	.85	1.50
26	1.55	1.45	1.70	1.60	2.70	1.30	1.10	1.40	1.10	.90	.80	3.00
27	1.45	1.45	1.70	1.45	1.80	1.30	1.15	1.20	1.00	*.70	.90	3.00
28	1.40	1.45	1.40	1.45	1.50	1.20	1.20	2.00	1.00	*.60	.90	21.00
29	1.40	......	1.40	1.45	1.50	1.15	1.15	1.50	1.80	*.70	.90	16.00
30	1.40	......	2.30	1.45	1.45	1.20	1.10	1.40	1.80	*.70	.90	8.00
31	1.40	......	13.10	......	1.40	......	1.10	1.40	......	.80	......	4.00

*Water was being held back by dams above in the morning when readings were made; 0.8 is assumed as minimum for October.

Rating table for Big Sandy Creek at Dadeville, Ala., for 1900 and *1901.*

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
0.8	67	4.4	1,868	8.0	3,740	11.6	5,612
0.9	85	4.5	1,920	8.1	3,792	11.7	5,664
1.0	115	4.6	1,972	8.2	3,844	11.8	5,716
1.1	152	4.7	2,024	8.3	3,896	11.9	5,768
1.2	204	4.8	2,076	8.4	3,948	12.0	5,820
1.3	256	4.9	2,128	8.5	4,000	12.1	5,872
1.4	308	5.0	2,180	8.6	4,052	12.2	5,924
1.5	360	5.1	2,232	8.7	4,104	12.3	5,976
1.6	412	5.2	2,284	8.8	4,156	12.4	6,028
1.7	464	5.3	2,336	8.9	4,208	12.5	6,080
1.8	516	5.4	2,388	9.0	4,260	12.6	6,132
1.9	568	5.5	2,440	9.1	4,312	12.7	6,184
2.0	620	5.6	2,492	9.2	4,364	12.8	6,236
2.1	672	5.7	2,544	9.3	4,416	12.9	6,288
2.2	724	5.8	2,596	9.4	4,468	13.0	6,340
2.3	776	5.9	2,648	9.5	4,520	13.1	6,392
2.4	828	6.0	2,700	9.6	4,572	13.2	6,444
2.5	880	6.1	2,752	9.7	4,624	13.3	6,496
2.6	932	6.2	2,804	9.8	4,676	13.4	6,548
2.7	984	6.3	2,856	9.9	4,728	13.5	6,600
2.8	1,036	6.4	2,908	10.0	4,780	13.6	6,652
2.9	1,088	6.5	2,960	10.1	4,832	13.7	6,704
3.0	1,140	6.6	3,012	10.2	4,884	13.8	6,756
3.1	1,192	6.7	3,064	10.3	4,936	13.9	6,808
3.2	1,244	6.8	3,116	10.4	4,988	14.0	6,860
3.3	1,296	6.9	3,168	10.5	5,040	14.1	6,912
3.4	1,348	7.0	3,220	10.6	5,092	14.2	6,964
3.5	1,400	7.1	3,272	10.7	5,144	14.3	7,016
3.6	1,452	7.2	3,324	10.8	5,196	14.4	7,068
3.7	1,504	7.3	3,376	10.9	5,248	14.5	7,120
3.8	1,556	7.4	3,428	11.0	5,300	14.6	7,172
3.9	1,608	7.5	3,480	11.1	5,352	14.7	7,224
4.0	1,660	7.6	3,532	11.2	5,404	14.8	7,276
4.1	1,712	7.7	3,584	11.3	5,456	14.9	7,328
4.2	1,764	7.8	3,636	11.4	5,508	15.0	7,380
4.3	1,816	7.9	3,688	11.5	5,560		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Big Sandy Creek near Dadeville, Ala.

[Drainage area, 195 square miles.]

Month.	Discharge in second-feet.			Total in acre-ft.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-ft. per sq. mile.
1900.						
August	655	80	207	12,728	1.22	1.06
September	3,150	80	355	21,124	2.03	1.82
October	2,670	80	264	16,233	1.56	1.35
November	870	110	261	15,531	1.50	1.34
December	3,870	150	560	34,433	3.31	2.87

Estimated monthly discharge of Big Sandy Creek near Dadeville, Ala.

[Drainage area, 195 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean	Depth in inches.	Second-ft. per sq. mile.
1901.					
January	880	308	425	2.51	2.18
February	2,700	282	545	2.90	2.78
March	6,392	256	552	3.26	2.83
April	3,428	334	689	3.94	3.53
May	3,220	230	480	2.84	2.46
June	2,492	178	523	2.99	2.68
July	516	152	227	1.34	1.16
August	2,180	115	369	2.18	1.89
September	620	67	257	1.47	1.32
October	1,764	*45	462	2.73	2.37
November	115	67	92	.52	.47
December	10,500	85	1,265	7.48	6.49
The year	10,500	*45	490	34.16	2.51

*See foot note under gage heights for 1901.

Minimum monthly discharge of Big Sandy Creek at Dadeville, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent of the theoretical power.

[Drainage area, 195 square miles.]

	1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January	......	......	......	308	28	7
February	......	......	......	282	26	2
March	......	......	......	256	23	3
April	......	......	......	334	30	5
May	......	......	......	230	21	1
June	......	......	......	178	16	2
July	......	......	......	152	14	9
August	80	7	4	115	10	2
September	80	7	1	67	6	1
October	80	7	3	*45	*4	1
November	110	10	1	67	6	3
December	150	14	5	85	8	2

*NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

*See foot note under gage heights for 1901.

A survey made in July, 1900, of Big Sandy Creek from its mouth to the new bridge near Dadeville, Ala., showed a total fall of 157 feet in a distance of 65,000 feet, or about 12 miles.

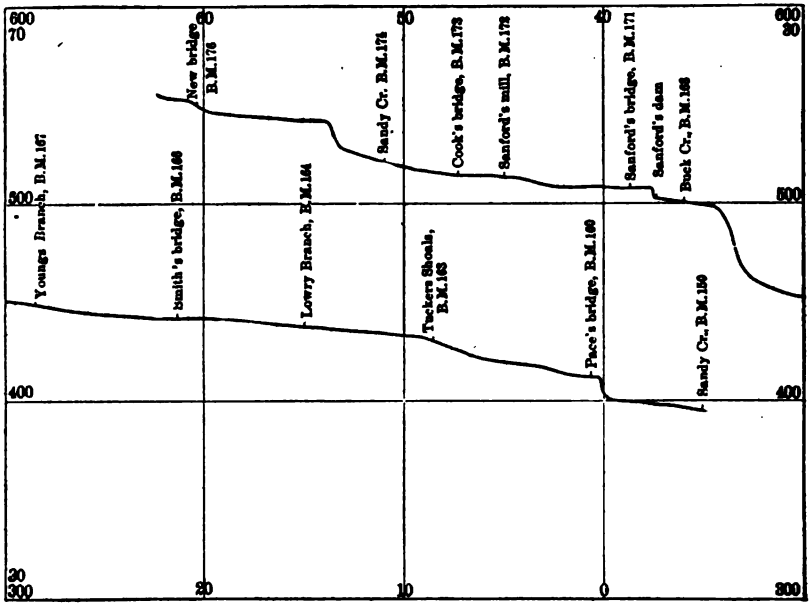

Fig. 7.—Profile of Big Sandy Creek from mouth to new bridge near Dadeville, Ala.

*NOTE.—The numbers 0, 10..70, represent thousand feet stations.

The profile resulting from the survey is reproduced in Fig. 7. The following list of distances and elevations of water and bench marks shows the fall of the creek from point to point.

Elevations and bench marks along Big Sandy Creek between its mouth and the new bridge near Dadeville, Ala.

Distance above mouth.	Description or location.	Bench mark elevation above sea level.	Elevation above sea level.
0	Bench mark No. 150, dead stump at mouth of creek..	398.08	....
0	Water at mouth of Big Sandy Creek................	....	393.80
5,000	Water below Pace's dam	....	402.00
5,000	Water above Pace's dam	....	412.10
5,600	Bench mark No. 160, big pine on north side, 175 feet above Pace's bridge	422.30	....
8,000	Creek surface	....	416.00
10,000	At point of Ivy Bend	....	419.00
11,700	Bench mark No. 162, large walnut at Tucker's house	503.85	....
13,500	Bench mark No. 163, small oak at Tucker's fish trap	432.85	....
13,500	Water above Tucker's fish trap	....	430.00
20,000	Bench mark No. 164, large sycamore at mouth of Lowry branch	445.20	....
20,000	Water at mouth of Lowry branch....................	....	436.10
26,500	Bench mark No. 166, oak post at north end of Smith's bridge	463.95	....
26,000	Water at Smith's bridge	....	441.70
26,500	Zero of U. S. G. S. gage at Dadeville	440.50	....
33,500	Bench mark No. 167, wahoo tree at mouth of Young branch	559.58	....
33,500	Water at mouth of Young branch	....	446.50
35,360	Water at Barnes basin	....	452.30
37,930	Water at foot of Black Shoals........................	....	465.00
39,300	Water at top of Black Shoals........................	....	496.30
41,100	Water at mouth of Buck Creek........................	....	497.30
41,100	Bench mark No. 168, small double oak at mouth of Buck Creek	503.65	....
41,900	Eddy water below Sanford's dam	....	500.00
42,550	Bench mark No. 169, hickory at Sanfords' mill......	522.10	....
42,550	Floor of Sanford's mill	514.00	....
43,770	Water at Sanford's bridge above dam................	....	506.70
45,580	Water at head of Sanford Pond	....	506.70
50,000	Water at second shoal above Sanford Pond	....	512.50
52,340	Bench mark No. 173, large white oak near north end of Cook's bridge	539.35	....
52,340	Water at Cook's bridge	....	513.80
56,120	Water opposite mouth of Chattasofka Creek.........	....	520.60
56,120	Bench mark, 16-inch water oak on west bank of Chattasofka Creek, 50 feet above mouth...........	527.20	....
58,620	Water at top of old factory shoal	....	540.15
65,350	Water at new bridge	....	550.80
65,350	Bench mark on upstream end of sill on west end of new bridge	562.30	....
65,350	Bench mark No. 176, 6-inch maple at new bridge....	563.00	....

Water supply of this creek is shown by the foregoing records of Dadeville Hydrographic Station at Smith's Bridge.

The best shoal on this creek is the Sanford and Black Shoal, near Dadeville, which has a fall of 85.8 feet, in a distance of 5.2 miles. With a dam 54 feet high, and a canal 1,370 feet long, a practical working head of 80 feet can be developed, having 1 foot extra for grade of canal, and 4 feet extra for storage at top of dam. The foregoing record shows that from

August 1, 1900, to December 31, 1901, covering a record of 515 days, there were only 37 days in which the flow at Smith's Bridge was less than 115 cubic feet per second. It is, therefore, plain that during the last two years such a plant would have realized, for 90 per cent. of the time, not less than 800 net horse power continuously, 24 hours per day; and that by running 11 hours per day, 6 days per week, and storing the water during the time that the wheels are standing, there would have been 2,000 H. P. or more for use during factory hours, for 90 per cent. of the time during the last two years. By applying the rating table to the gage heights, and finding the discharge for each individual day, the exact power obtainable can be calculated, due allowance being made for the storage capacity, and equalizing effect of the dam.

Of course, this 85 foot fall can be developed in other ways. A low dam, and long canal can be used, or two separate powers can be developed.

6. HILLABEE CREEK, NEAR ALEXANDER CITY, ALABAMA.

This station, which was established August 20, 1900, by J. R. Hall, is located 6½ miles northeast of Alexander City, on the road leading from that town to Newsite. The gage, which is graduated to feet and tenths, and is placed vertically, is in two sections, the short section, which reads from 0 to 5.50 feet, being fastened to a post in the edge of the water on the north bank 20 feet from the upstream side of the bridge, the long section, which reads from 5.50 feet to 16 feet, being fastened to the upstream end of the first pier on the north bank, and arranged so that when water rises above the short section the readings are made from the long one, both sections being easily read from the north approach to the bridge. The initial point of sounding is on the south side of the first pier on the north bank. The gage is refer[illegible] to a bench mark at the top of a chord on the dawnstream s[illegible] of the bridge at the second pier from the north bank, and is 27.6 feet above the zero of the gage. The bridge is in three spans, having a total length of 276 feet, with a north approach of 116 feet and a south approach of 124 feet, making a total, over all, of 516 feet. The observer is J. H. Chisholm, a farmer, postoffice address Alexander City, Ala. During 1900 the following measurements were made by James R. Hall:

August 29: Gage height, 1.40 feet; discharge 184 second-feet.
November 28: Gage height, 2 feet; discharge, 390 second-feet.

Daily gage height of Hillabee Creek at Alexander City, Ala., for 1900.

Day.	Aug.	Sept.	Oct.	Nov.	Dec	Day.	Aug.	Sept.	Oct.	Nov.	Dec
1	......	2.30	1.30	1.60	1.90	17	......	2.60	1.30	1.50	2.70
2	......	2.30	1.10	2.60	1.90	18	......	2.20	1.30	1.40	2.80
3	......	1.60	1.10	6.80	1.80	19	......	1.60	1.20	1.50	3.00
4	......	1.40	1.10	3.20	1.90	20	......	1.50	1.20	1.60	2.90
5	......	1.30	3.20	2.20	1.80	21	......	1.50	1.20	1.70	6.00
6	......	1.20	2.00	1.80	1.90	22	......	1.40	1.90	2.10	4.00
7	......	1.20	2.80	1.70	1.80	23	......	1.20	5.90	1.90	3.00
8	......	1.10	2.60	1.70	1.70	24	......	1.30	2.90	1.90	2.90
9	......	1.10	2.40	1.80	1.70	25	......	1.40	2.10	5.10	2.90
10	......	1.20	2.30	1.70	1.70	26	......	1.30	1.90	2.90	2.80
11	......	1.10	2.30	1.70	1.70	27	......	1.40	1.80	2.40	2.60
12	......	1.10	1.80	1.70	1.70	28	......	1.30	1.70	2.00	2.50
13	......	1.10	1.60	1.70	1.80	29	1.40	1.40	1.60	1.90	2.50
14	......	1.10	1.40	1.70	3.80	30	1.30	1.30	1.50	1.90	5.80
15	......	8.10	1.40	1.70	2.90	31	1.80	......	1.50	......	5.70
16	......	5.00	1.20	1.60	2.80						

Daily gage height of Hillabee Creek at Alexander City, Ala., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	5.00	2.40	2.30	5.20	2.50	2.50	2.50	1.80	2.60	1.20	1.00	1.00
2	4.90	2.40	2.30	4.40	2.50	2.40	2.50	1.40	2.00	1.20	1.00	1.00
3	4.90	4.60	2.40	4.80	2.50	3.00	2.40	1.40	1.40	1.10	1.00	2.00
4	4.70	9.40	2.40	3.10	2.40	2.50	2.30	1.20	1.20	1.10	1.00	1.60
5	3.90	6.00	2.30	2.90	2.40	2.50	2.00	1.10	1.10	1.10	1.30	1.40
6	3.60	4.10	2.20	2.80	2.40	2.60	1.80	1.10	1.10	1.20	1.10	[illegible]
7	3.60	3.60	2.10	2.70	2.40	2.50	2.90	1.10	1.10	1.40	1.10	1.20
8	3.40	3.10	2.10	2.60	2.40	2.50	2.10	1.00	1.10	1.20	1.00	1.20
9	2.60	3.60	2.10	2.60	2.30	2.40	1.80	1.20	1.10	1.20	1.00	1.20
10	2.50	3.00	2.40	2.50	2.30	2.40	1.80	1.20	1.10	1.20	1.00	1.90
11	8.00	2.90	2.50	2.50	2.30	2.30	1.70	1.10	1.00	1.60	1.00	1.50
12	7.60	2.90	2.30	2.40	2.20	2.00	1.60	1.10	1.00	2.00	1.00	1.40
13	7.00	2.80	2.20	3.10	2.50	2.10	1.50	1.20	1.20	2.90	1.00	1.40
14	5.90	3.00	2.20	2.90	2.30	2.00	1.40	1.60	2.50	1.60	1.00	2.00
15	4.50	3.10	2.30	2.80	2.50	2.00	1.30	2.10	2.40	1.40	1.00	3.00
16	4.30	2.60	2.40	2.70	2.20	1.90	1.40	4.40	2.40	1.20	1.00	3.00
17	4.00	2.60	2.20	2.60	2.20	2.20	1.30	2.90	2.00	1.00	1.00	2.80
18	3.50	2.40	2.20	2.60	2.10	1.90	3.40	2.00	1.80	1.00	1.00	[illegible]
19	3.40	2.60	2.10	10.00	2.10	1.80	2.20	2.00	1.60	1.00	1.30	2.60
20	3.00	2.70	2.10	3.20	2.90	1.80	1.80	4.00	1.40	1.00	1.30	2.00
21	2.90	2.60	3.00	3.10	3.80	1.70	2.00	4.10	1.20	1.00	1.30	1.50
22	2.90	2.40	2.40	3.00	2.90	1.70	1.90	3.40	1.40	1.00	1.30	1.50
23	2.80	2.60	2.30	2.90	2.50	1.60	1.80	3.10	1.20	1.00	1.30	1.50
24	2.60	2.60	2.80	2.80	2.50	1.60	1.80	2.90	1.10	1.00	1.30	1.60
25	2.50	2.50	2.70	2.70	2.40	1.70	1.70	2.20	1.10	1.00	1.20	1.60
26	2.60	2.40	3.50	2.60	3.90	1.70	1.70	2.20	1.20	1.00	1.20	1.70
27	2.60	2.40	3.00	2.50	2.80	1.80	1.40	2.10	2.10	1.00	1.10	1.70
28	2.50	2.40	2.70	2.50	2.60	1.80	1.60	3.80	1.60	1.00	1.10	1.80
29	2.40	......	2.60	2.50	2.50	1.70	1.40	3.60	1.40	1.00	1.10	11.00
30	2.40	......	2.70	2.50	2.30	2.60	1.40	3.40	1.20	1.00	1.10	4.90
31	2.40	......	5.20	......	2.90	....	2.00	3.00	......	1.00	......	3.90

Rating table for Hillabee Creek at Alexander City, Ala., for years 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Feet.*	*Feet.*	*Second Ft.*
1.0	138	2.4	566	3.8	1,182
1.1	146	2.5	610	3.9	1,226
1.2	156	2.6	564	4.0	1,270
1.3	169	2.7	698	4.1	1,314
1.4	184	2.8	742	4.2	1,358
1.5	204	2.9	786	4.3	1,402
1.6	230	3.0	830	4.4	1,446
1.7	263	3.1	874	4.5	1,490
1.8	303	3.2	918	4.6	1,534
1.9	346	3.3	962	4.7	1,578
2.0	390	3.4	1,006	4.8	1,622
2.1	434	3.5	1,050	4.9	1,666
2.2	478	3.6	1,094	5.0	1,710
2.3	522	3.7	1,138		

NOTE.—This table applied to the foregoing "Daily Gage Heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Hillabee Creek near Alexander City, Ala.

[Drainage area, 214 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1900.					
September	3,074	146	370	1.93	1.73
October	2,106	146	387	2.09	1.81
November	2,502	184	471	2.45	2.20
December	2,150	263	716	3.86	3.35
1901.					
January	3,030	566	1,198	6.46	5.60
February	3,646	566	920	4.48	4.30
March	1,798	434	617	3.32	2.88
April	3,910	566	911	4.75	4.26
May	1,226	434	624	3.37	2.92
June	830	230	439	2.29	2.05
July	1,006	169	357	1.93	1.67
August	1,446	138	535	2.89	2.50
September	654	138	249	1.29	1.16
October	786	138	181	.98	.85
November	169	138	148	.77	.69
December	4,350	138	526	2.84	2.46
The year	4,350	138	559	35.37	2.61

Minimum monthly discharge of Hillabee Creek at Alexander City, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent of the theoretical power.

[Drainage area, 214 square miles.]

	1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January	......	......	......	566	51	3
February	......	......	......	566	51	7
March	......	......	......	434	40	5
April	......	......	......	566	51	1
May	......	......	......	434	40	2
June	......	......	......	230	21	2
July	......	......	......	169	15	2
August	169	15	1	138	13	1
September	146	13	6	138	13	2
October	146	13	3	138	13	15
November	184	17	1	138	13	15
December	263	24	5	138	13	2

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

7. ALABAMA TRIBUTARIES OF THE TALLAPOOSA RIVER, FROM MILSTEAD UP.

From which side.	Name of Stream.	Point on stream.	Drainage area, sq. miles.	Estimated discharge cu. ft. per sec. low water 1900-1901.	Net H.P. per ft. of fall on 80 per cent. turbine.
Left..	Uphapee Creek	Mouth of Creek	450	45	4.1
Left..	Uphapee Creek	Chehaw, Ala	360	40	3.6
Left..	Sougahatchee Creek	Mouth of Creek	240	48	4.3
Right	Cedar Creek	Mouth of Creek	55	14	1.3
Left..	Wind Creek	Mouth of Creek	25	8	0.7
Right	Kowaliga Creek	Mouth of Creek	135	40	3.6
Right	Kowaliga Creek	Kowaliga, Ala	115	35	3.2
Left..	Blue Creek	Mouth of Creek	60	20	1.8
Left..	Big Sandy Creek	Mouth of Creek	200	70	6.3
Left..	Big Sandy Creek	Smith's Bridge	195	67	6.1
Right	Elkahatchee Creek	Mouth of Creek	75	37	3.3
Right	Hillabee Creek	Mouth of Creek	220	141	12.8
Right	Hillabee Creek	Chisholme's Bridge	214	138	12.6
Right	Emuckfaw Creek	Mouth of Creek	78	46	4.2
Left..	Cohoasanocsa Creek	Mouth of Creek	70	42	3.8
Left..	High Pine Creek	Mouth of Creek	82	49	4.4
Right	Hurricane Creek	Mouth of Creek	14	8	0.7
Left..	Corn House Creek	Mouth of Creek	72	43	3.9
Right	Crooked Creek	Mouth of Creek	95	57	5.2
Right	Fox Creek	Mouth of Creek	37	22	2.0
Left..	Little Tallapoosa River	Mouth of River	590	354	32.2
Left..	Little Tallapoosa River	Ala.-Ga. State Line	311	186	16.9
Left..	Tallapoosa River	Above Little Tallapoosa River	767	460	41.8
Right	Ketchepedrakee Creek	Mouth of Creek	49	29	2.6
Right	Cane Creek	Mouth of Creek	55	33	3.0
Right	Muscadine Creek	Mouth of Creek	36	21	1.9
Right	Tallapoosa River	Ala.-Ga. State Line	302	181	16.4

NOTE.—To find the net horse power available at a shoal on one of the streams near a given point, for low water 1900-1901, multiply the total fall of the shoal by the "Net H. P. per foot of fall' in this table.

All of these tributaries to the Tallapoosa River are in the Crystalline region, and are very precipitous streams, having fine shoals all along their courses.

No State or Government Surveys have ever been made to determine their profiles, and it is, therefore, impossible at present to make a detailed statement of the water powers. The tabulated statement given above shows the cubic feet per second flowing in the streams, at certain places during low season of ordinary years, like 1900 and 1901.

This flow at any point multiplied by the total practical fall in feet that can be brought upon a water wheel on the given stream at that point, and divided by 11 gives the net available horse power at that point, during low season of a year like 1900 or 1901.

The "Cubic feet per second" flowing at the given points and the corresponding "Drainage areas" can be used to get by pro-

portion the discharge at other points of same stream whose drainage areas are known.

Actual discharge measurements have been made on these streams at various points and at various stages of water, as is shown by the following list of Miscellaneous Discharge Measurements. As that date of these measurements are given, the stage of water as related to minimum for 1900-1901 can be approximated by noting the stage at regular stations on the same dates.

Miscellanous discharge measurements made by James R. Hall on tributaries of Tallapoosa River.

1900.

August 2—Sougahatchee Creek, Meaders bridge; discharge 125 second-feet.

August 3—Blue Creek, Susanna, Ala., postoffice; 34 second-feet.

August 28—Elkahatchee Creek, Island Home postoffice; discharge, 184 second-feet.

August 30—Timber Cut Creek, Near Welches Ferry; discharge, 18 second-feet.

December 12—Chattasofka Creek, New Bridge, near Dadeville; discharge, 35 second-feet.

1901.

February 11—Wind Creek, Starr's bridge, near Meltons Mill postoffice; discharge, 66 second-feet.

February 11—Sougahatchee Creek, Lovelady's bridge, near Thadeus; discharge 453 second-feet.

February 13—Blue Creek, Farrows Mill, Susanna postoffice; discharge 117 second-feet.

February 13—Channahatchee Creek, Freeman's Mill, Channahatchee postoffice; discharge 80 second-feet.

February 27—Kowaliga Creek, Benson's bridge, Kowaliga postoffice; discharge 154 second-feet.

March 5—Emuckfaw Creek, Hamlett's Mill, Zana postoffice; discharge 113 second-feet.

March 11—Moore's Creek, near Dudleyville; discharge 29 second-feet.

March 12—Chattahaspa Creek, Scott's Mill, near Tiller Crossroads postoffice; discharge 203 second-feet.

March 12—Cohoasanocsa Creek, Leverett's Mill, near Milltown postoffice; discharge 122 second-feet.

March 12—High Pine Creek, Lile's Gin, Happy Land postoffice; discharge 89 second-feet.

March 12—Beaver Dam Creek, near Louina postoffice; discharge 30 second-feet.

March 13—Corn House Creek, Swann's Store, near Level Road postoffice; discharge 31 second-feet.

March 13—Wild Cat Creek, Murphy's Mill, near Gay postoffice; discharge, 32 second-feet.

March 13—Tallapoosa River, below mouth of Little Tallapoosa River, near Goldburg; discharge, 2,400 second-feet.

March 13—Crooked Creek, near Goldberg; discharge 183 second-feet.

March 13—Hurricane Creek, near Almond postoffice; discharge, 29 second-feet.

CHAPTER III.

COOSA RIVER AND TRIBUTARIES.

The Regular Stations that will be used in the folowing discussion are: Riverside, Ala., and Rome, Ga., on the Coosa River; and Nottingham, Ala., on Talladega Creek. Numerous miscellaneous discharge measurements at other points will also be used.

Under the heading of each station all the investigations made at the station are given, together with the facts deduced therefrom.

1. RIVERSIDE STATION ON COOSA RIVER.

This station is at Riverside, Ala., in the Springville quadrangle of the United States Geological Survey map, in latitude 33° 37' and longitude 85° 12', at the bridge of the Southern Railway, Georgia Pacific Division, across the Coosa River. The river here flows in a southerly direction, the railroad running from east to west. The town of Riverside is on the right or west bank of the river, and the railroad depot is about 1,000 feet west of the bridge, which is of iron and about 30 feet above low water. Beginning at the left bank, there are two spans of 154 feet each; then a drawbridge 220 feet, revolving on a large center pier; then a stationery span, 80 feet in length, to west or right bank abutment. There is no running water at low stages under the last-named span.

At low water the flowing river is 480 feet wide, including three piers, and is from 4 to 10 feet deep. Very little of the current is too slow to turn any meter. It is somewhat irregular, as there are shoals and some old cribs just above the bridge, but for all stages it is probably the best station that can be found on the river at a bridge and easy of access.

On September 8, 1896, a discharge measurement was made by B. M. Hall, and two bench marks were established. On September 22, 1896, another discharge measurement was made, a wire gage was put in, and Mr. J. W. Foster, sawyer at a large sawmill about 300 feet distant, on right bank of river, below the bridge, was employed as observer.

The initial point is top of left abutment at the edge toward the river, on the downstream side of the bridge, from which side soundings and meter measurements are made. The rod of wire gage is nailed to outside guard rail, downstream side, next to the last panel of stationary bridge before reaching the pier at end of draw span. The rod is 14 feet long and divided to feet and tenths. The bench mark is the top of capstone on the large circular center pier of turn span. It is 26.80 feet above datum of gage at downstream side of pier.

The drainage area is 6,850 square miles, and is mapped on atlas sheets Springville, Anniston, Gadsden, Fort Payne, Rome, Tallapoosa, Marietta, Cartersville, Suwanee, Ellijay, Dalton, Cleveland, Ringgold, and Stevenson of the United States Geological Survey.

The following discharge measurements were made during 1896 by B. M. Hall and others:

September 8: Gage height, 0.70 feet; discharge, 1,630 second-feet.
September 25: Gage height, 0.50 feet; discharge, 1,403 second-feet.
October 30: Gage height, 0.88 feet; discharge, 1,986 second-feet.
December 21: Gage height, 1.57 feet; discharge, 3,272 second-feet.

Daily gage height in feet of Coosa river at Riverside, Ala., for 1896.

Day.	Sept.	Oct.	Nov.	Dec.	Day.	Sept.	Oct.	Nov.	Dec.
1	......	0.60	1.10	1.30	17	......	0.55	4.70	2.10
2	......	1.75	1.40	2.10	18	......	.65	4.20	2.20
3	......	3.10	1.20	4.38	19	......	.80	3.20	2.00
4	......	2.75	1.10	3.80	20	......	.85	2.30	1.80
5	......	2.00	1.05	3.20	21	......	.75	1.50	1.70
6	......	1.50	1.10	2.50	22	......	.70	1.40	1.50
7	......	1.20	1.20	2.20	23	......	.60	1.35	1.45
8	......	.85	2.55	1.90	24	......	.55	1.30	1.40
9	......	.70	2.30	1.70	25	......	.60	1.25	1.35
10	......	.60	1.90	1.60	26	......	.70	1.20	1.30
11	......	.65	1.30	1.55	27	.45	.80	1.15	1.25
12	......	.60	1.60	1.55	28	.45	.85	1.15	1.20
13	......	.60	2.25	1.60	29	.45	.90	1.10	1.10
14	......	.60	2.70	1.60	30	.50	.95	1.20	1.10
15	......	.55	4.00	1.80	31	......	.85	......	1.10
16	......	.55	5.20	2.00					

Rating table for Coosa River at Riverside, Ala., for 1896.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Ft.*	*Feet.*	*Second Ft.*
0.5	1,400	2.1	4,630	3.7	9,640
0.6	1,500	2.2	4,920	3.8	9,980
0.7	1,630	2.3	5,200	3.9	10,330
0.8	1,780	2.4	5,500	4.0	10,680
0.9	1,930	2.5	5,800	4.1	11,030
1.0	2,100	2.6	6,100	4.2	11,390
1.1	2,280	2.7	6,400	4.3	11,750
1.2	2,480	2.8	6,700	4.4	12,110
1.3	2,680	2.9	7,010	4.5	12,470
1.4	2,880	3.0	7,320	4.6	12,840
1.5	3,090	3.1	7,640	4.7	13,210
1.6	3,320	3.2	7,970	4.8	13,580
1.7	3,560	3.3	8,300	4.9	13,950
1.8	3,820	3.4	8,630	5.0	14 330
1.9	4,080	3.5	8,960	5.1	14,710
2.0	4,360	3.6	9,300	5.2	15,100

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1897 by Max Hall and others:

March 31: Gage height, 4.53 feet; discharge, 12,515 second-feet.
June 17: Gage height, 1.54 feet; discharge, 3,747 second-feet.
July 21: Gage height, 5.55 feet; discharge, 16,925 second-feet.
August 20: Gage height, 2.58 feet; discharge, 6,174 second-feet.
November 29: Gage height, 0.80 feet; discharge, 1,854 second-feet.

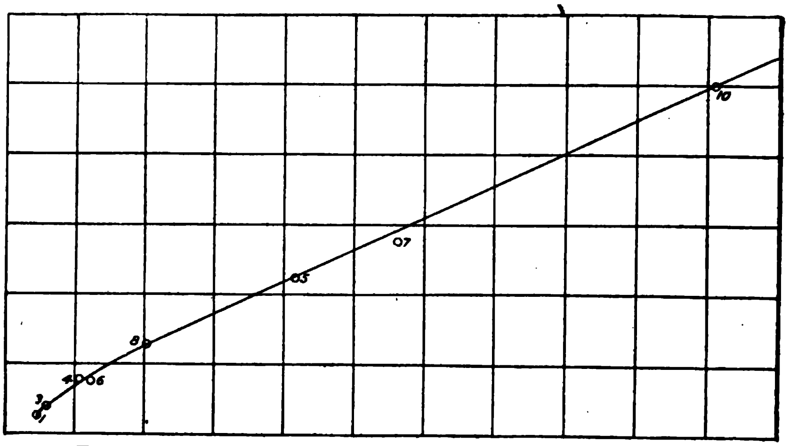

Fig. 8.—Rating curve for Riverside station on Coosa River, Ala.

Daily gage height, in feet, of Coosa River, at Riverside, Ala., for 1897.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	1.10	2.00	5.00	4.30	3.40	1.90	1.45	2.00	1.20	0.50	0.70	0.80
2..........	1.10	2.50	4.50	4.45	3.10	1.90	1.45	1.80	1.10	.50	.70	.90
3..........	1.10	5.35	4.25	5.20	3.05	1.90	1.40	1.60	1.30	.50	.70	.95
4..........	1.10	7.35	3.90	7.00	3.60	1.85	1.40	1.50	1.60	.50	.65	1.20
5..........	1.10	7.70	4.20	8.60	3.20	1.85	1.45	1.45	1.30	.45	.80	2.50
6..........	1.20	7.90	5.80	9.50	3.00	1.80	1.50	1.40	1.20	.45	1.05	3.00
7..........	1.25	9.00	11.40	10.50	3.80	1.90	1.50	1.50	1.10	.45	1.15	2.90
8..........	1.30	7.70	13.30	11.15	3.70	2.15	2.40	1.50	1.00	.45	1.10	2.40
9..........	1.35	6.40	12.55	12.15	2.65	2.10	2.30	1.60	.90	.45	1.00	2.15
10..........	1.35	5.90	12.65	11.90	2.60	1.90	2.05	1.70	.85	.45	.95	2.00
11..........	1.35	5.20	12.70	10.70	2.50	1.90	2.50	1.70	.80	.40	.85	1.70
12..........	1.30	7.35	12.80	9.10	2.55	2.00	2.70	2.00	.80	.40	.85	1.60
13..........	1.40	8.30	13.45	7.30	2.65	1.90	2.50	2.50	.75	.45	.85	1.60
14..........	2.00	8.20	14.80	6.05	2.10	1.85	2.00	2.30	.75	.45	.85	2.00
15..........	3.50	7.50	14.60	5.60	3.90	1.60	1.80	2.00	.80	1.45	.80	2.50
16..........	4.00	6.60	14.80	5.30	4.00	1.70	1.70	1.80	.85	1.65	.75	3.00
17..........	4.90	5.70	14.70	5.60	4.00	1.50	1.80	1.60	.85	1.40	.70	3.30
18..........	5.35	5.00	14.70	5.40	3.60	1.60	1.95	1.50	.80	1.35	.70	3.15
19..........	5.00	4.50	14.50	5.00	3.20	1.90	2.00	1.90	.80	1.20	.70	2.65
20..........	4.80	4.00	15.30	4.60	3.00	2.00	3.00	2.60	.75	1.00	.65	2.10
21..........	6.50	4.60	14.90	4.30	2.70	1.80	5.20	2.00	.75	.90	.65	2.20
22..........	7.00	4.65	14.70	4.00	2.35	1.70	6.40	1.70	.70	.85	.65	2.80
23..........	7.35	6.00	14.50	3.80	2.30	1.60	8.00	1.60	.70	.80	.65	4.20
24..........	7.00	7.90	13.70	3.60	2.25	1.55	6.20	1.70	.70	.70	.65	4.85
25..........	5.40	9.00	12.20	3.40	2.25	1.50	4.50	1.75	.65	.80	.65	4.95
26..........	4.70	9.00	10.60	3.30	2.15	1.45	4.00	1.60	.65	.75	.65	4.55
27..........	3.80	8.00	8.50	3.25	2.05	1.45	3.00	1.60	.60	.60	.65	3.85
28..........	3.00	6.20	6.50	2.20	2.00	1.40	2.60	1.50	.55	.65	.65	3.20
29..........	2.70	......	5.30	3.10	2.00	1.45	2.50	1.40	.55	.80	.70	2.95
30..........	2.50	......	4.90	3.20	1.95	1.45	3.00	1.35	.55	.75	.75	2.85
31..........	2.20	......	4.60	......	1.90	....	2.60	1.30	......	.70	......	2.50

Rating table for Coosa River at Riverside, Ala., for 1897.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Ft.*	*Feet.*	*Second Ft.*
0.4	1,350	2.0	4,520	5.0	14,046
0.5	1,400	2.2	5,100	6.0	17,306
0.6	1,500	2.4	5,700	7.0	20,566
0.7	1,650	2.6	6,300	8.0	23,826
0.8	1,820	2.8	6,910	9.0	27,086
0.9	2,010	3.0	7,530	10.0	30,346
1.0	2,210	3.2	8,178	11.0	33,606
1.2	2,630	3.4	8,830	12.0	36,866
1.4	3,070	3.6	9,482	13.0	40,126
1.6	3,540	3.8	10,134	14.0	43,386
1.8	4,020	4.0	10,786		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1898 by Max Hall and others:

January 27: Gage height, 10.00 feet; discharge, 30,359 second-feet.
March 9: Gage height, 1.60 feet; discharge, 3,538 second-feet.
May 3: Gage height, 3.22 feet; discharge, 7,758 second-feet.
May 25: Gage height, 1.39 feet; discharge, 3,172 second-feet.
August 3: Gage height, 3.92 feet; discharge, 9,524 second-feet.
September 7: Gage height, 11.05 feet; discharge, 37,811 second-feet.
October 19: Gage height, 6.80 feet; discharge, 14,484 second-feet.
November 22: Gage height, 5.85 feet; discharge, 16,384 second-feet.

Daily gage height, in feet, of Coosa River at Riverside, Ala., for 1898.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	2.30	6.00	1.65	6.80	3.90	1.30	1.15	4.25	2.20	2.20	2.60	3.70
2	2.15	5.25	1.70	7.50	3.60	1.25	1.05	4.00	1.80	1.80	2.50	4.00
3	2.10	4.00	1.80	6.80	3.30	1.20	1.00	4.10	1.75	1.70	2.50	3.90
4	2.00	3.25	1.80	5.50	3.05	1.20	.95	4.00	5.80	2.00	2.45	3.70
5	1.90	3.00	1.80	5.80	2.90	1.30	.95	3.30	9.30	6.80	2.40	3.70
6	1.85	2.80	1.75	9.30	2.70	1.25	.90	4.00	10.20	11.20	2.40	3.90
7	1.75	2.75	1.70	10.50	2.55	1.20	.95	5.50	11.00	11.90	2.40	4.00
8	1.70	2.70	1.70	10.80	2.40	1.10	1.00	5.30	11.30	15.80	2.40	4.00
9	1.65	2.60	1.65	10.40	2.30	1.05	1.15	4.50	11.60	14.70	2.45	3.70
10	1.60	2.50	1.65	8.90	2.20	1.05	1.65	4.30	10.80	12.50	2.55	3.30
11	1.60	2.40	1.60	7.50	2.15	1.00	2.15	4.50	8.70	12.00	2.75	3.25
12	1.65	2.30	1.60	6.00	2.10	1.48	2.15	4.70	5.80	11.20	2.75	3.10
13	1.80	2.30	1.70	5.00	2.00	1.10	2.10	6.70	4.75	8.80	2.70	3.00
14	2.00	2.20	1.80	4.40	1.95	1.25	2.15	5.90	4.10	5.50	2.65	2.90
15	3.10	2.10	2.00	4.00	1.90	1.15	2.05	4.70	3.40	4.40	2.70	2.80
16	3.00	2.00	2.25	3.70	1.85	1.00	2.30	3.70	3.00	3.60	2.80	2.65
17	2.80	1.95	3.00	3.50	1.80	1.65	3.10	3.00	2.70	3.00	3.00	[illegible]
18	2.60	1.90	4.75	4.00	1.75	1.70	3.05	2.75	2.50	3.50	3.15	2.60
19	2.80	1.85	5.50	5.10	1.70	1.65	2.50	2.55	2.25	5.40	3.25	2.70
20	3.00	1.80	4.70	5.80	1.60	1.55	1.90	2.45	2.20	6.40	3.70	2.90
21	4.10	1.80	4.00	5.50	1.70	1.95	1.65	2.40	2.15	6.30	4.20	4.00
22	5.80	1.80	3.25	4.00	1.65	2.10	1.50	2.40	2.20	6.00	5.15	3.80
23	6.05	1.75	3.00	4.50	1.55	2.30	1.35	2.35	2.55	5.80	7.00	3.40
24	6.50	1.75	2.75	5.75	1.50	2.50	1.25	2.30	3.55	5.00	5.90	3.00
25	7.20	1.70	2.30	7.10	1.45	2.05	1.20	2.15	4.30	4.35	5.20	2.75
26	9.00	1.70	2.15	7.80	1.40	1.75	1.40	2.00	3.90	4.00	4.90	2.70
27	10.20	1.70	2.00	7.45	1.55	1.50	2.35	1.80	3.40	3.75	4.60	2.50
28	10.65	1.65	2.00	6.45	1.70	1.60	3.15	2.00	3.15	3.30	4.20	2.40
29	10.45	......	2.30	5,50	1.60	1.45	3.10	2.50	3.00	3.00	4.00	2.30
30	9.45	......	3.00	4.75	1.45	1.30	3.40	3.00	2.75	2.75	3.80	2.30
31	7.55	......	4.50	......	1.35	....	4.00	2.60	......	2.70	......	2.40

Rating table for Coosa River at Riverside, Ala., for 1898.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*	*Feet.*	*Second-feet.*
0.9	2,140	4.7	12,301	8.5	25,335	12.3	46,960
1.0	2,320	4.8	12,644	8.6	25,678	12.4	47,680
1.1	2,520	4.9	12,987	8.7	26,021	12.5	48,400
1.2	2,720	5.0	13,330	8.8	26,364	12.6	49,120
1.3	2,925	5.1	13,673	8.9	26,707	12.7	49,840
1.4	3,130	5.2	14,016	9.0	27,050	12.8	50,560
1.5	3,340	5.3	14,359	9.1	27,433	12.9	51,280
1.6	3,550	5.4	14,702	9.2	27,800	13.0	52,000
1.7	3,760	5.5	15,045	9.3	28,175	13.1	52,720
1.8	3,970	5.6	15,388	9.4	28,550	13.2	53,440
1.9	4,185	5.7	15,731	9.5	28,965	13.3	54,160
2.0	4,400	5.8	16,074	9.6	29,380	13.4	54,885
2.1	4,620	5.9	16,417	9.7	29,815	13.5	55,600
2.2	4,840	6.0	16,760	9.8	30,250	13.6	56,320
2.3	5,070	6.1	17,103	9.9	30,725	13.7	57,040
2.4	5,300	6.2	17,446	10.0	31,200	13.8	57,760
2.5	5,540	6.3	17,789	10.1	31,725	13.9	58,480
2.6	5,780	6.4	18,132	10.2	32,250	14.0	59,200
2.7	6,030	6.5	18,475	10.3	32,825	14.1	59,920
2.8	6,280	6.6	18,818	10.4	33,400	14.2	60,640
2.9	6,540	6.7	19,161	10.5	34,067	14.3	61,360
3.0	6,800	6.8	19,540	10.6	34,725	14.4	62,080
3.1	7,080	6.9	19,847	10.7	35,442	14.5	62,800
3.2	7,360	7.0	20,190	10.8	36,160	14.6	63,520
3.3	7,655	7.1	20,533	10.9	36,880	14.7	64,240
3.4	7,950	7.2	20,876	11.0	37,600	14.8	64,960
3.5	8,260	7.3	21,219	11.1	38,320	14.9	65,680
3.6	8,570	7.4	21,562	11.2	39,040	15.0	66,400
3.7	8,895	7.5	21,905	11.3	39,760	15.1	67,120
3.8	9,220	7.6	22,248	11.4	40,480	15.2	67,840
3.9	9,560	7.7	22,591	11.5	41,200	15.3	68,560
4.0	9,900	7.8	22,934	11.6	41,920	15.4	69,280
4.1	12,243	7.9	23,277	11.7	42,640	15.5	70,000
4.2	10,586	8.0	23,620	11.8	43,360	15.6	70,720
4.3	10,929	8.1	23,963	11.9	44,080	15.7	71,440
4.4	11,272	8.2	24,306	12.0	44,800	15.8	72,160
4.5	11,615	8.3	24,649	12.1	45,520	15.9	72,880
4.6	11,958	8.4	24,992	12.2	46,240	16.0	73,600

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1899 by Max Hall and others:

April 26: Gage height, 9.00 feet; discharge, 29,069 second-feet.
May 3: Gage height, 4.05 feet; discharge, 10,592 second-feet.
May 20: Gage height, 2.70 feet; discharge, 6,276 second-feet.
June 14: Gage height, 2.20 feet; discharge, 5,010 second-feet.
August 26: Gage height, 1.42 feet; discharge, 3,791 second-feet.
September 23: Gage height, 1.00 foot; discharge, 2,457 second-feet.
November 7: Gage height, 0.85 foot; discharge, 2,271 second-feet.
December 9: Gage height, 1.20 feet; discharge, 2,727 second-feet.

Daily gage height, in feet, of Coosa River at Riverside, Ala., for 1899.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	2.80	5.90	12.10	10.30	5.00	2.70	1.70	3.95	2.30	0.90	0.95	2.60
2	2.75	6.30	12.20	10.20	4.50	2.80	1.70	3.00	2.40	.90	.95	2.00
3	2.75	7.50	12.30	10.00	4.20	2.80	1.65	2.30	2.80	.90	.95	1.60
4	2.80	7.40	12.10	9.80	3.95	2.60	1.60	2.00	2.40	.90	.95	1.50
5	2.80	9.10	10.10	8.90	3.80	2.30	1.50	1.90	2.10	.90	.95	1.45
6	3.00	12.10	9.00	8.75	3.75	2.10	1.50	1.75	2.00	.90	.95	1.40
7	3.50	14.10	8.00	9.00	3.60	2.00	1.45	1.65	1.85	.90	.95	1.35
8	4.30	14.30	7.50	10.00	4.00	2.00	1.40	1.50	1.40	.90	.95	1.30
9	4.20	14.30	7.25	12.30	3.85	1.95	1.70	1.50	1.30	.95	.95	1.30
10	4.40	14.10	7.00	12.00	3.60	1.95	1.60	1.55	1.25	1.20	.95	1.35
11	5.20	13.80	6.15	11.70	3.45	1.95	1.50	1.55	1.25	1.30	.95	1.40
12	5.90	13.00	5.20	10.00	3.30	1.95	1.50	1.60	2.20	1.40	.95	5.80
13	5.60	12.00	5.50	8.90	3.20	2.00	1.40	1.50	2.50	1.30	.95	8.25
14	5.00	10.90	7.50	7.90	3.00	2.15	1.40	1.45	2.65	1.20	1.00	8.00
15	4.70	8.70	8.30	6.30	3.00	2.80	1.30	1.50	2.00	1.20	1.00	6.00
16	4.90	7.90	16.00	5.55	2.95	3.20	1.30	1.50	1.40	1.20	1.00	4.50
17	5.00	7.60	17.40	5.25	2.95	2.95	1.30	1.50	1.25	1.10	1.00	3.75
18	4.90	7.80	17.00	5.10	2.80	2.50	1.20	1.55	1.20	1.00	1.00	3.60
19	4.70	8.10	16.50	5.00	2.80	2.25	1.30	1.50	1.20	.95	1.00	3.40
20	4.60	8.20	16.30	4.80	2.75	2 [illegible]	1.50	1.45	1.10	.95	1.00	3.00
21	4.20	8.00	16.35	4.60	2.75	1.80	1.50	1.45	1.00	.90	.95	2.85
22	4.00	7.65	16.20	4.30	2.70	1.70	1.90	1.35	.95	.90	.95	2.75
23	3.90	8.00	15.90	4.75	2.70	1.70	3.20	1.30	1.00	.95	.95	3.00
24	3.90	8.10	15.70	5.65	2.65	1.60	4.70	1.30	1.00	1.20	.95	5.40
25	4.00	7.30	15.50	8.90	2.60	1.75	3.60	1.30	1.00	1.15	1.00	6.40
26	4.25	7.00	14.90	9.00	2.50	1.60	3.20	1.60	1.00	1.00	2.15	7.10
27	4.15	8.30	13.25	8.90	2.45	1.60	3.00	1.20	.95	1.00	2.90	7.00
28	4.00	11.00	11.00	8.30	2.35	1.65	3.60	1.10	.95	.95	3.00	6.60
29	3.90	......	8.00	6.90	2.30	1.70	4.20	1.50	.90	.95	3.00	6.00
30	3.75	......	7.90	5.45	2.20	1.65	5.20	2.10	.90	.90	2.75	4.85
31	3.70	......	8.50	......	2.70	....	4.75	2.10	......	.95	......	4.00

Rating table for Coosa river at Riverside, Ala., for 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second feet.*	*Feet.*	*Second feet.*	*Feet.*	*Second feet*
0.9	2,330	5.2	14,740	9.5	30,650	13.8	46,560
1.0	2,460	5.3	15,110	9.6	31,020	13.9	46,930
1.1	2,600	5.4	15,480	9.7	31,390	14.0	47,300
1.2	2,760	5.5	15,850	9.8	31,760	14.1	47,670
1.3	2,920	5.6	16,220	9.9	32,130	14.2	48,040
1.4	3,100	5.7	16,590	10.0	32,500	14.3	48,410
1.5	3,300	5.8	16,960	10.1	32,870	14.4	48,780
1.6	3,500	5.9	17,330	10.2	33,240	14.5	49,150
1.7	3,720	6.0	17,700	10.3	33,610	14.6	49,520
1.8	3,940	6.1	18,070	10.4	33,980	14.7	49,890
1.9	4,160	6.2	18,440	10.5	34,350	14.8	50,260
2.0	4,400	6.3	18,810	10.6	34,720	14.9	50,630
2.1	4,600	6.4	19,180	10.7	35,090	15.0	51,000
2.2	4,900	6.5	19,550	10.8	35,460	15.1	51,370
2.3	5,160	6.6	19,920	10.9	35,830	15.2	51,740
2.4	5,430	6.7	20,290	11.0	36,200	15.3	52,110
2.5	5,700	6.8	20,660	11.1	36,570	15.4	52,480
2.6	5,970	6.9	21,030	11.2	36,940	15.5	52,850
2.7	6,250	7.0	21,400	11.3	37,310	15.6	53,220
2.8	6,530	7.1	21,770	11.4	37,680	15.7	53,590
2.9	6,810	7.2	22,140	11.5	38,050	15.8	53,960
3.0	7,100	7.3	22,510	11.6	38,420	15.9	54,330
3.1	7,400	7.4	22,880	11.7	38,790	16.0	54,700
3.2	7,700	7.5	23,250	11.8	39,160	16.1	55,070
3.3	8,010	7.6	23,620	11.9	39,530	16.2	55,440
3.4	8,330	7.7	23,990	12.0	39,900	16.3	55,810
3.5	8,650	7.8	24,360	12.1	40,270	16.4	56,280
3.6	8,970	7.9	24,730	12.2	40,640	16.5	56,650
3.7	9,290	8.0	25,100	12.3	41,010	16.6	57,020
3.8	9,620	8.1	25,470	12.4	41,380	16.7	57,390
3.9	9,950	8.2	25,840	12.5	41,750	16.8	57,760
4.0	10,300	8.3	26,210	12.6	42,120	16.9	58,130
4.1	10,670	8.4	26,580	12.7	42,490	17.0	58,400
4.2	11,040	8.5	26,950	12.8	42,860	17.1	58,770
4.3	11,410	8.6	27,320	12.9	43,230	17.2	59,140
4.4	11,780	8.7	27,690	13.0	43,600	17.3	59,510
4.5	12,150	8.8	28,060	13.1	43,970	17.4	59,880
4.6	12,520	8.9	28,430	13.2	44,340	17.5	60,250
4.7	12,890	9.0	28,800	13.3	44,710	17.6	60,620
4.8	13,260	9.1	29,170	13.4	45,080	17.7	60,990
4.9	13,630	9.2	29,540	13.5	45,450	17.8	61,360
5.0	14,000	9.3	29,910	13.6	45,720	17.9	61,730
5.1	14,370	9.4	30,280	13.7	46,190	18.0	62,100

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1900 by Max Hall and others:

February 10: Gage height, 5.03 feet; discharge, 13,493 second-feet.

March 21: Gage height, 12.50 feet; discharge, 43,759 second-feet.

May 5: Gage height, 4.15 feet; discharge, 11,196 second-feet.

August 21: Gage height, 2.32 feet; discharge, 5,609 second-feet.

December 28: Gage height, 4.25 feet; discharge, 11,335 second-feet.

Daily gage height, in feet, of Coosa River, near Riverside, Ala., for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	3.50	2.70	6.90	6.65	5.00	2.75	11.60	4.70	1.85	1.55	2.30	5.75
2	3.00	2.65	7.55	6.25	5.30	2.80	10.10	3.90	2.00	1.55	2.25	4.35
3	2.50	2.60	6.90	6.00	5.30	2.90	8.90	3.00	2.20	1.50	2.50	3.75
4	2.40	2.50	6.25	5.60	4.75	2.60	8.20	2.75	2.10	1.50	[illegible]	3.40
5	2.15	2.60	5.40	5.10	4.30	2.70	7.50	2.55	2.00	1.50	2.50	3.30
6	2.05	2.80	5.00	4.90	4.20	3.45	6.45	2.40	1.80	1.45	2.40	4.35
7	1.95	2.95	4.90	4.75	4.00	3.90	5.50	2.25	1.70	1.40	2.40	6.05
8	1.95	3.00	6.00	4.40	3.65	[illegible]	4.70	2.15	1.60	1.50	2.35	5.40
9	2.00	3.75	8.75	4.35	3.40	7.05	5.00	2.10	1.50	2.20	2.30	4.80
10	2.00	4.25	10.00	4.30	3.30	8.30	4.30	2.00	1.45	2.35	2.30	4.00
11	2.10	5.80	10.55	6.50	3.15	8.00	4.20	2.00	1.35	3.85	2.15	3.60
12	3.50	6.50	10.05	12.40	2.95	7.70	4.10	1.90	1.30	3.60	2.10	3.15
13	6.00	13.30	8.75	12.90	2.70	6.70	5.65	2.25	1.25	3.80	2.10	2.95
14	7.40	15.30	7.50	11.70	2.70	4.30	4.65	2.00	1.20	2.80	2.00	2.80
15	7.00	15.20	5.60	9.50	2.65	4.50	3.75	1.30	3.35	3.00	1.90	2.70
16	6.40	14.50	6.00	7.20	2.65	4.70	3.60	1.85	6.00	2.90	1.80	2.65
17	5.10	14.00	6.30	12.40	2.60	5.00	3.50	2.00	7.00	2.80	1.75	2.60
18	4.00	13.25	6.00	18.10	2.60	4.90	3.35	2.00	7.50	2.65	1.70	2.55
19	4.25	12.80	6.50	17.55	2.60	6.90	3.10	2.20	6.00	2.50	1.80	2.55
20	8.00	12.10	10.00	15.65	2.60	6.90	3.00	2.10	4.35	2.40	2.00	3.00
21	9.70	9.00	12.20	13.95	2.65	6.45	2.90	2.20	3.20	2.30	2.50	3.30
22	10.00	7.80	12.85	13.15	3.20	6.10	2.70	2.06	2.50	2.20	4.00	5.20
23	9.40	6.80	12.60	12.65	2.90	[illegible]	2.45	2.00	2.00	2.15	3.80	7.00
24	8.75	7.20	11.80	12.20	3.00	11.35	2.50	1.95	1.90	3.00	3.20	7.30
25	7.75	6.90	10.60	10.80	3.25	12.50	2.60	1.90	1.85	5.25	3.10	5.80
26	6.00	6.50	10.30	9.15	3.10	14.10	2.50	2.20	1.80	7.50	3.00	6.35
27	4.10	5.25	10.20	7.90	3.20	[illegible]	2.60	2.10	1.80	5.00	4.35	5.90
28	3.60	5.00	9.85	6.50	3.00	14.60	3.70	2.00	1.65	3.80	6.40	4.90
29	3.30	......	9.50	5.70	2.80	[illegible]	5.70	1.95	1.60	3.00	9.20	4.30
30	3.00	......	8.50	5.35	2.70	[illegible]	5.30	1.90	1.55	2.65	8.20	4.00
31	2.70	......	7.20	......	2.60	[illegible]	5.90	1.90	......	2.50	......	6.50

The following discharge measurements were made during 1901 by Max Hall and others:

January 8: Gage height, 3.85 feet; discharge, 9,572 second-feet.
March 18: Gage height, 3.70 feet; discharge, 9,333 second-feet.
August 24: Gage height, 12.95 feet ; discharge, 44,554 second-feet.
November 14: Gage height, 1.70 feet; discharge, 4,039 second-feet.

Daily gage height, in feet, of Coosa River, at Riverside, Ala., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jui	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7.30	6.00	3.55	14.35	4.80	5.20	3.00	2.15	5.60	2.70	1.90	1.85
2	7.35	6.50	3.50	14.40	4.60	8.20	2.90	2.10	5.00	4.00	1.85	1.90
3	6.50	9.00	3.50	13.30	4.30	8.25	2.85	2.10	4.50	3.20	1.85	1.95
4	6.00	10.60	3.50	11.90	4.15	7.20	2.80	2.05	4.30	3.00	1.85	1.95
5	5.50	11.00	3.40	10.40	4.00	5.75	2.80	2.00	3.65	2.90	1.80	2.20
6	5.00	12.00	3.30	10.30	3.95	5.00	2.75	2.20	3.30	2.75	1.80	2.10
7	4.25	11.90	3.20	9.00	3.90	4.80	2.75	4.10	3.05	2.60	1.80	2.00
8	3.95	11.50	3.10	7.25	3.75	4.30	2.70	4.80	3.00	2.50	1.85	2.00
9	3.70	9.90	3.10	6.50	3.60	4.20	3.50	4.25	2.90	2.30	1.85	2.10
10	3.60	9.60	3.40	5.60	3.45	6.20	4.00	3.50	2.85	2.30	1.80	2.10
11	6.50	9.90	5.50	5.00	3.25	6.00	3.50	2.90	2.75	2.25	1.80	2.05
12	14.10	9.60	6.50	4.80	3.15	5.00	2.90	2.75	2.70	2.30	1.80	2.00
13	15.70	8.90	7.50	4.80	3.10	4.25	2.50	2.60	2.65	3.00	1.80	2.00
14	15.40	7.60	7.00	6.50	3.10	3.75	2.40	3.20	2.65	2.80	1.75	2.90
15	15.10	6.50	6.30	7.50	3.00	3.75	2.35	3.20	2.60	2.70	1.75	11.50
16	14.90	5.80	5.25	8.30	2.95	3.80	2.20	3.40	2.85	2.50	1.80	12.00
17	14.30	5.45	4.25	7.80	2.95	3.80	3.15	5.30	3.90	2.45	1.80	12.50
18	13.90	5.00	3.75	6.50	2.90	4.90	2.90	9.60	5.60	2.60	1.80	12.40
19	13.30	4.80	3.55	10.50	2.90	5.00	2.90	9.65	6.30	2.40	1.80	11.00
20	11.30	4.60	3.55	14.00	2.85	4.50	3.20	10.00	7.50	2.35	1.75	10.20
21	8.30	4.35	3.75	14.50	4.00	3.90	3.00	11.50	7.20	2.30	1.75	9.20
22	6.25	4.20	3.70	14.30	8.20	3.60	2.95	11.00	6.00	2.30	1.75	8.00
23	5.30	4.00	3.50	13.50	9.90	3.50	2.90	11.50	4.50	2.25	1.75	4.50
24	4.60	3.90	4.30	12.50	10.75	3.25	2.75	12.50	3.30	2.20	1.85	3.60
25	5.30	3.85	13.90	11.30	11.85	3.15	2.70	12.90	3.00	2.10	1.90	4.10
26	5.80	3.65	15.90	9.90	11.90	3.00	2.60	12.40	2.70	2.10	2.10	4.60
27	6.30	3.65	15.20	7.90	11.80	2.90	2.40	12.00	2.60	2.10	2.00	5.10
28	6.40	3.60	14.70	6.80	11.00	3.00	2.20	11.50	2.50	2.05	2.00	6.50
29	5.85	.....	14.25	5.90	9.60	2.90	2.30	9.95	2.65	2.05	1.85	11.50
30	5.50	.....	14.60	5.20	6.20	3.10	2.40	8.35	2.60	2.00	1.85	15.60
31	5.80	......	15.50	......	4.60	....	2.20	6.85	......	1.95	......	16.00

Rating table for Coosa River at Riverside, Ala., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*
1.0	2,460	5.6	15,900	10.2	33,900	14.8	52,300
1.1	2,610	5.7	16,250	10.3	34,300	14.9	52,700
1.2	2,760	5.8	16,600	10.4	34,700	15.0	53,100
1.3	2,930	5.9	16,950	10.5	35,100	15.1	53,500
1.4	3,100	6.0	17,300	10.6	35,500	15.2	53,900
1.5	3,300	6.1	17,680	10.7	35,900	15.3	54,300
1.6	3,500	6.2	18,060	10.8	36,300	15.4	54,700
1.7	3,720	6.3	18,440	10.9	36,700	15.5	55,100
1.8	3,940	6.4	18,820	11.0	37,100	15.6	55,500
1.9	4,170	6.5	19,200	11.1	37,500	15.7	55,900
2.0	4,400	6.6	19,580	11.2	37,900	15.8	56,300
2.1	4,650	6.7	19,960	11.3	38,300	15.9	56,700
2.2	4,900	6.8	20,340	11.4	38,700	16.0	57,100
2.3	5,165	6.9	20,720	11.5	39,100	16.1	57,500
2.4	5,430	7.0	21,100	11.6	39,500	16.2	57,900
2.5	5,700	7.1	21,500	11.7	39,900	16.3	58,300
2.6	5,970	7.2	21,900	11.8	40,300	16.4	58,700
2.7	6,250	7.3	22,300	11.9	40,700	16.5	59,100
2.8	6,530	7.4	22,700	12.0	41,100	16.6	59,500
2.9	6,845	7.5	23,100	12.1	41,500	16.7	59,900
3.0	7,100	7.6	23,500	12.2	41,900	16.8	60,300
3.1	7,400	7.7	23,900	12.3	42,300	16.9	60,700
3.2	7,700	7.8	24,300	12.4	42,700	17.0	61,100
3.3	8,015	7.9	24,700	12.5	43,100	17.1	61,500
3.4	8,330	8.0	25,100	12.6	43,500	17.2	61,900
3.5	8,650	8.1	25,500	12.7	43,900	17.3	62,300
3.6	8,970	8.2	25,900	12.8	44,300	17.4	62,700
3.7	9,295	8.3	26,300	12.9	44,700	17.5	63,100
3.8	9,620	8.4	26,700	13.0	45,100	17.6	63,500
3.9	9,960	8.5	27,100	13.1	45,500	17.7	63,900
4.0	10,300	8.6	27,500	13.2	45,900	17.8	64,300
4.1	10,650	8.7	27,900	13.3	46,300	17.9	64,700
4.2	11,000	8.8	28,300	13.4	46,700	18.0	65,100
4.3	11,350	8.9	28,700	13.5	47,100	18.1	65,500
4.4	11,700	9.0	29,100	13.6	47,500	18.2	65,900
4.5	12,050	9.1	29,500	13.7	47,900	18.3	66,300
4.6	12,400	9.2	29,900	13.8	48,300	18.4	66,700
4.7	12,750	9.3	30,300	13.9	48,700	18.5	67,100
4.8	13,100	9.4	30,700	14.0	49,100	18.6	67,500
4.9	13,450	9.5	31,100	14.1	49,500	18.7	67,900
5.0	13,800	9.6	31,500	14.2	49,900	18.8	68,300
5.1	14,150	9.7	31,900	14.3	50,300	18.9	68,700
5.2	14,500	9.8	32,300	14.4	50,700	19.0	69,100
5.3	14,850	9.9	32,700	14.5	51,100		
5.4	15,200	10.0	33,100	14.6	51,500		
5.5	15,550	10.1	33,500	14.7	51,900		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Coosa River at Riverside, Ala.

[Drainage area, 6,850 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-feet per square mile.
1896.						
September 27 to 30	1,400	1,350	1,363	10,812	0.03	0.20
October	7,640	1,450	2,218	136,380	0.37	0.32
November	15,100	2,190	4,637	275,921	0.75	0.68
December	12,110	2,280	4,125	253,636	0.69	0.60
1897.						
January	21,707	2,420	8,434	518,590	1.42	1.23
February	27,086	4,520	18,658	1,036,230	2.83	2.72
March	47,624	10,460	32,481	1,997,180	5.47	4.74
April	37,355	5,100	17,698	1,053,105	2.87	2.58
May	10,786	4,270	7,040	432,875	1.19	1.03
June	4,950	3,070	3,915	232,960	0.63	0.57
July	23,826	3,070	7,142	439,145	1.20	1.04
August	6,300	2,850	3,870	237,960	0.64	0.56
September	3,540	1,440	1,976	117,580	0.32	0.29
October	3,660	1,350	1,819	111,845	0.31	0.27
November	2,525	1,570	1,786	106,275	0.29	0.26
December	13,883	1,820	6,566	403,730	1.10	0.96
1898.						
January	35,084	3,550	11,572	711,539	1.95	1.69
February	16,760	3,655	5,763	320,161	0.87	0.84
March	15,045	3,550	5,852	359,828	0.68	0.59
April	36,160	8,260	18,133	1,078,986	2.95	2.65
May	9,560	3,028	4,684	288,010	0.78	0.68
June	5,540	2,320	3,281	195,233	0.54	0.48
July	9,900	2,140	4,289	263,722	0.72	0.63
August	19,161	3,970	8,758	538,512	1.48	1.28
September	41,920	3,865	13,927	828,712	2.26	2.03
October	72,160	3,760	19,936	1,225,825	3.36	2.91
November	20,190	5,300	8,375	498,345	1.36	1.22
December	9,900	5,070	7,376	453,535	1.25	1.08
1899.						
January	17,330	6,390	10,865	668,063	1.78	1.54
February	48,410	17,330	30,974	1,720,209	4.56	4.38
March	60,880	14,740	38,094	2,342,309	6.21	5.39
April	41,010	11,410	24,915	1,482,545	3.94	3.53
May	14,000	4,900	7,742	476,037	1.27	1.10
June	7,700	3,500	4,771	283,894	0.75	0.68
July	14,740	2,760	5,318	326,991	0.86	0.75
August	10,125	2,600	3,806	234,022	0.62	0.54
September	6,530	2,330	3,555	211,537	0.56	0.50
October	3,100	2,330	2,510	154,334	0.41	0.36
November	7,100	2,395	3,086	183,630	0.49	0.44
December	26,025	2,920	10,631	653,675	1.73	1.50

Estimated monthly discharge of Coosa River near Riverside, Ala.

[Drainage area, 7,065 square miles.]

Month	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second feet per square mile.
1900.						
January	33,100	4,280	13,344	820,491	2.18	1.89
February	54,300	5,700	23,487	1,304,402	3.45	3.32
March	44,500	13,450	26,822	1,649,221	4.38	3.80
April	65,500	11,350	29,813	1,773,997	4.71	4.22
May	14,850	5,970	8,198	504,075	1.34	1.16
June	51,500	5,970	22,216	1,321,944	3.51	3.14
July	39,500	5,565	13,610	836,846	2.23	1.93
August	12,750	4,050	5,147	316,477	0.84	0.73
September	23,100	2,760	6,483	385,765	1.03	0.92
October	23,100	3,100	6,910	424,879	1.13	0.98
November	29,900	3,720	7,673	456,575	1.22	1.09
December	22,300	5,835	11,773	723,894	1.93	1.67
The year	65,500	2,760	14,623	10518566	27.95	2.07

Month.	Discharge in second-feet			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1901.					
January	55,900	8,970	26,089	4.25	3.69
February	41,100	8,970	21,784	3.21	3.08
March	56,700	7,400	20,613	3.37	2.92
April	51,100	14,500	30,616	4.83	4.33
May	40,700	6,670	16,195	2.64	2.29
June	26,100	6,810	12,335	1.95	1.75
July	10,300	4,900	6,535	1.07	0.93
August	44,700	4,400	20,370	3.32	2.88
September	23,100	5,700	9,977	1.57	1.41
October	10,300	4,280	5,694	0.93	0.81
November	4,650	3,830	4,016	0.64	0.57
December	57,100	4,050	18,885	3.08	2.67
The year	57,100	3,830	16,092	30.86	2.28

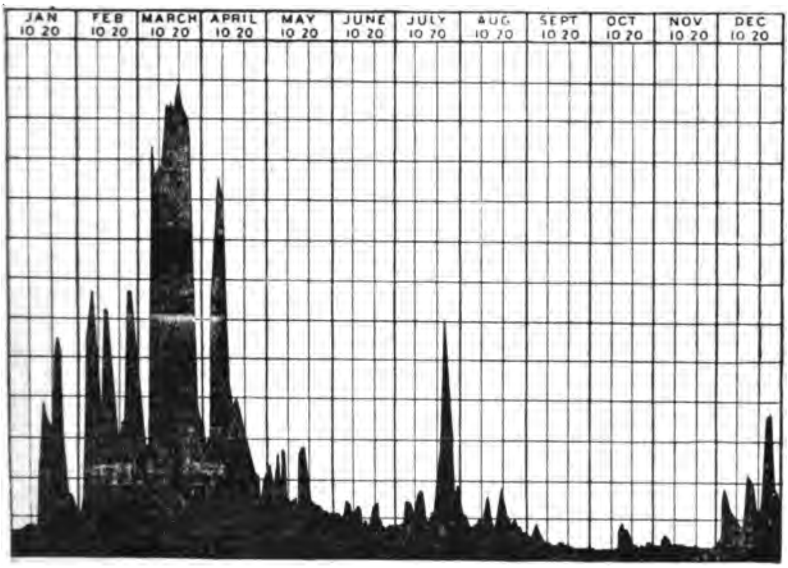

Fig. 9.—Discharge of Coosa River at Riverside, Ala., 1897.

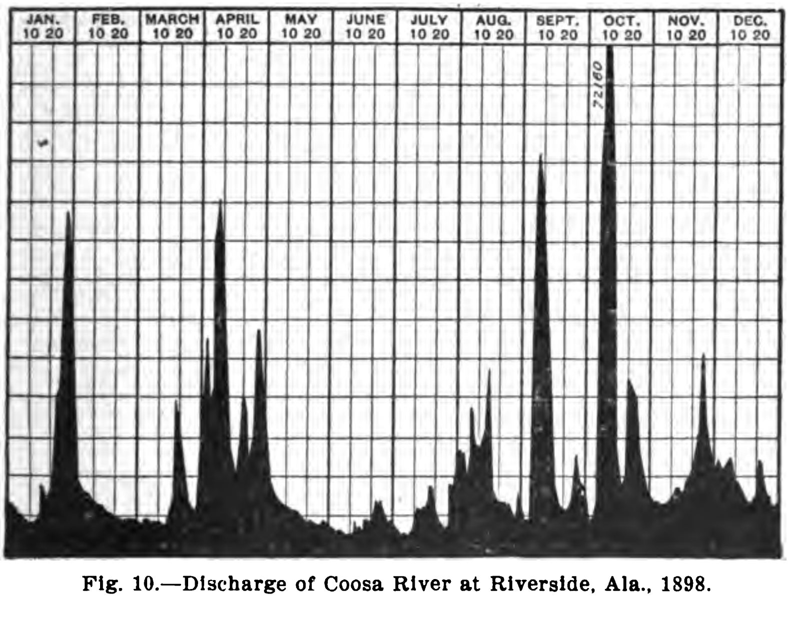

Fig. 10.—Discharge of Coosa River at Riverside, Ala., 1898.

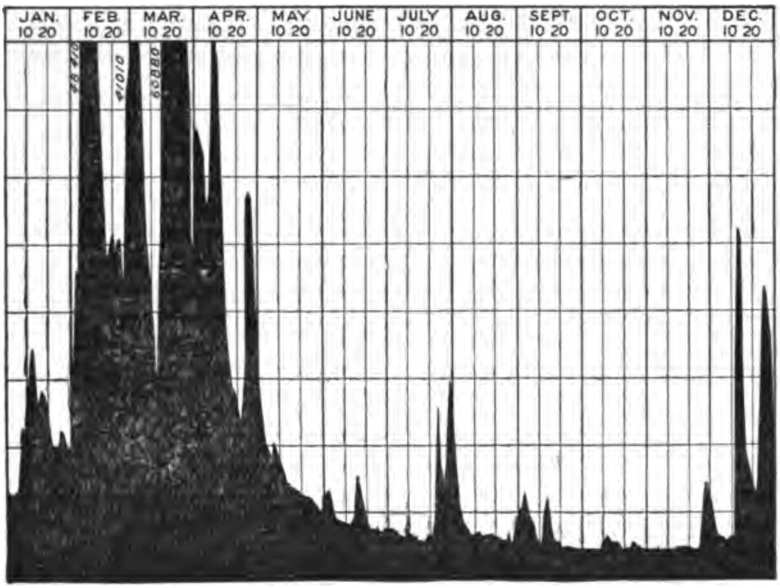

Fig. 11.—Discharge of Coosa River at Riverside, Ala., 1899.

Minimum monthly discharge of Coosa River at Riverside, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent of theoretical power.

[Drainage area, 6,850 square miles.]

	1899			1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January ..	6,390	581	2	4,285	390	2	8,970	815	1
February .	17,330	1,575	1	5,700	518	1	8,970	815	1
March ...	14,740	1,340	1	13,450	1,223	1	7,400	673	2
April	11,410	1,037	1	11,350	1,032	1	14,500	1,310	2
May	4,900	445	1	5,970	543	5	6,687	608	1
June	3,500	318	3	5,970	543	1	6,810	619	2
July	2,760	251	1	5,565	506	1	4,900	445	3
August	2,600	236	1	4,050	369	1	4,400	400	1
September	2,330	212	2	2,760	251	1	5,700	518	1
October ...	2,330	212	11	3,100	282	1	4,285	390	1
November .	2,395	218	17	3,720	338	1	3,830	348	6
December .	2,920	265	2	5,835	530	2	4,050	368	1

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

2. COOSA RIVER AT ROME, GEORGIA.

Coosa River is formed by the junction of Etowah and Oostanaula rivers at Rome, Ga. The drainage area is 4,006 square miles. Both of the tributary rivers rise in the northern part of Georgia and flow for the most part through a hilly, broken country, well wooded, about one-fourth of the land being under cultivation. The Coosa River flows in a southwesterly direction into Alabama and joins the Tallapoosa 6 miles above Montgomery, Ala., to form Alabama River. Measurements of flow are made at Rome and at Riverside, 120 miles farther downstream. The measurements at Rome are made on the Oostanaula and Etowah just above their junction. Etowah River is measured at Second avenue bridge and the Oostanaula at Fifth avenue bridge in Rome, and the result added to give the flow of Coosa River. The gage height is taken from the United States Weather Bureau gage at Fifth avenue bridge, on the Oostanaula. There is practically no fall on Oostanaula River from Fifth avenue bridge to the junction, hence the gage is used as Coosa River gage and gives the fluctuations of Coosa River. This gage is a 4 by 6 inch timber, graduated to feet and tenths and fastened to the downstream left-hand corner of the first pier from the left bank. The zero of gage is 575.79 feet avove sea level. The United States Weather Bureau has maintained the station here for many years. It is now maintained only as a half-year station, from November 1 to April 30, inclusive, but W. M. Towers, the river observer, kindly reads the gage and furnishes the Survey with monthly reports of the daily gage heights for the entire year without charge. Mr. Towers has kept the records for many years and has predicted floods with great precision. The channel of the Etowah is straight, current swift and unobstructed, but the Oostanaula is rather sluggish and somewhat obstructed by piers. The banks are high, but liable to overflow in times of high water.

The following discharge measurements were made during 1896-97-98 by Max Hall and others:

1896—

September 29: Gage height, 0.20 feet; discharge, 1,209 second-feet.

1897—

May 7: Gage height, 2.75 feet; discharge, 4,646 second-feet.

October 5: Gage height, 0.15 feet; discharge, 990 second-feet.

1898—

May 11: Gage height, 1.90 feet; discharge, 2,946 second-feet.

September 17: Gage height, 2.60 feet; discharge, 3,913 second-feet.

October 11: Gage height, 5.05 feet; discharge, 8,324 second-feet.

October 22: Gage height, 4.10 feet; discharge, 6,489 second-feet.

November 30: Gage height, 3.90 feet; discharge, 6,039 second-feet.

Daily gage height, in feet, of Coosa River at Rome, Ga., for 1897...

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1.0	2.8	3.3	7.1	4.1	1.8	1.7	0.8	1.0	0.0	0.5	1.1
2	1.0	9.7	3.2	7.5	4.0	2.3	1.9	.7	.5	0.0	.9	1.0
3	1.0	11.5	3.1	8.2	3.5	2.0	1.0	1.2	.3	0.0	1.0	1.2
4	1.0	9.6	3.3	9.4	3.3	3.0	0.9	1.0	.5	.1	1.0	2.3
5	1.0	8.2	3.5	14.8	3.0	2.4	2.0	.8	.4	.1	1.0	3.2
6	1.3	5.2	7.6	18.9	3.0	2.0	1.9	.8	.3	.1	.8	3.7
7	1.1	5.0	19.7	17.0	3.0	2.0	1.9	1.9	.3	.1	.8	3.2
8	1.1	4.3	18.9	14.7	2.8	2.0	3.0	2.0	.2	.1	.8	2.2
9	1.0	5.0	15.4	12.1	2.6	2.0	2.1	2.0	.1	.1	.8	1.9
10	1.0	4.4	13.5	9.6	2.6	1.9	1.9	1.6	.0	.1	.7	1.7
11	.9	4.5	12.0	7.2	2.6	1.9	2.5	2.4	.0	.1	.7	1.5
12	.9	7.4	11.5	6.2	3.0	1.9	2.8	1.8	.0	1.1	.7	1.4
13	.9	8.7	18.6	5.8	3.4	1.8	2.0	1.3	.0	1.6	.7	1.3
14	2.8	7.2	21.3	5.0	4.0	1.7	1.6	.8	.0	1.3	.6	2.2
15	6.2	5.5	23.8	6.0	5.0	1.7	1.3	.6	.0	1.0	.0	4.0
16	5.0	4.5	23.4	7.4	4.0	2.0	1.0	.6	.0	.8	.6	3.5
17	3.5	4.0	22.6	7.0	3.3	2.8	5.2	2.1	.0	.7	.6	2.5
18	3.9	3.7	21.4	5.0	2.8	2.3	4.2	3.2	.1	.6	.6	2.2
19	5.0	3.4	19.7	4.5	2.7	2.0	4.8	2.4	.2	.6	.6	1.8
20	3.5	3.0	18.9	4.0	2.6	1.8	8.8	1.4	.2	.6	.6	1.7
21	8.7	4.0	17.7	3.	2.5	1.6	12.8	1.3	.2	1.5	.6	3.2
22	9.5	3.9	15.3	3.7	2.4	1.5	7.3	1.5	.2	1.3	.5	4.1
23	5.7	5.6	13.7	3.5	2.4	1.5	4.4	1.5	.2	1.0	.5	5.8
24	4.0	11.7	12.9	3.5	2.4	1.4	3.9	1.5	.2	.8	.5	5.3
25	3.5	8.6	9.1	3.5	2.3	1.3	2.6	1.1	.3	.8	.5	3.7
26	3.0	6.7	6.0	3.5	2.2	1.2	2.6	.8	.3	.7	.5	2.8
27	2.5	4.7	5.2	3.4	2.1	1.2	3.8	.5	.4	.7	.5	3.0
28	2.5	3.5	4.8	3.4	2.0	1.0	3.0	.4	.4	.7	.9	2.8
29	2.5	......	4.5	3.4	2.0	1.1	2.4	.4	.4	.6	1.1	2.3
30	3.8	......	4.2	3.2	1.9	2.0	1.4	.4	.4	.5	1.1	2.0
31	4.2	......	4.0	......	1.9	...	1.2	.5	......	.5	......	2.0

Daily gage height in feet, of Coosa River, at Rome, Ga., for 1898.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1..........	1.8	3.6	1.2	9.0	2.8	1.4	1.2	4.8	2.0	2.0	2.2	4.2
2..........	1.8	3.1	1.2	6.1	2.6	1.4	1.0	4.4	7.8	2.0	2.2	4.0
3..........	1.7	2.8	1.2	4.2	2.4	1.4	1.0	3.2	21.7	2.0	2.2	3.8
4..........	1.7	2.6	1.2	3.6	2.3	1.4	1.0	4.4	24.3	4.9	2.2	3.8
5..........	1.6	2.4	1.2	9.9	2.2	1.3	1.0	8.0	22.2	22.0	2.0	4.8
6..........	1.6	2.2	1.2	17.2	2.1	1.3	1.3	5.6	20.0	23.8	2.2	5.0
7..........	1.3	2.0	1.2	14.5	2.0	1.3	2.0	4.4	17.6	19.0	2.6	4.3
8..........	1.3	1.8	1.2	10.9	2.0	1.3	2.8	4.4	16.4	18.4	2.4	4.0
9..........	1.3	1.8	1.2	7.0	2.0	1.3	3.2	3.4	9.7	16.6	2.3	3.7
10..........	1.3	1.7	1.2	4.1	2.0	1.3	1.7	3.0	5.0	14.0	2.1	3.4
11..........	1.4	1.5	1.2	4.0	2.0	1.3	2.8	9.9	5.4	5.6	2.0	3.3
12..........	2.0	1.5	1.2	3.8	1.9	1.2	2.0	7.2	4.6	4.2	2.0	3.3
13..........	4.0	1.3	1.2	3.6	1.8	1.4	1.8	4.2	3.8	3.8	2.0	3.2
14..........	4.0	1.3	1.3	3.5	1.8	1.8	1.6	3.4	3.2	3.7	2.3	3.0
15..........	3.8	1.3	1.6	3.5	1.7	1.8	3.7	3.0	3.0	3.5	2.3	3.0
16..........	3.6	1.3	3.7	3.4	1.6	1.7	3.7	2.5	2.9	3.2	2.9	2.8
17..........	3.6	1.2	7.3	3.0	1.5	1.8	2.2	2.0	2.7	3.1	2.9	2.7
18..........	3.2	1.2	5.8	3.0	1.5	1.8	1.9	2.2	2.5	6.5	4.0	2.6
19..........	2.8	1.2	3.7	3.0	1.5	2.2	1.7	2.2	2.3	9.0	5.0	2.6
20..........	4.4	1.2	3.0	3.6	1.4	3.6	1.6	3.2	2.2	6.0	4.5	2.6
21..........	6.5	1.2	2.5	3.6	1.4	3.2	1.5	2.8	2.2	4.2	5.0	2.8
22..........	6.4	1.2	2.5	3.2	1.4	3.0	1.4	3.9	2.3	3.9	4.0	2.9
23..........	5.0	1.2	2.3	3.0	1.4	2.8	1.3	2.2	2.6	4.0	5.0	3.2
24..........	4.5	1.2	2.2	7.2	1.4	2.6	1.8	2.2	4.1	3.9	7.0	3.6
25..........	7.0	1.2	2.1	8.2	1.4	2.0	3.7	1.9	3.1	3.5	4.7	3.0
26..........	14.0	1.2	2.0	6.0	1.4	1.8	3.8	2.7	3.0	3.3	3.9	2.9
27..........	14.6	1.2	1.9	4.6	1.4	1.8	2.9	4.0	2.7	3.1	4.5	2.7
28..........	11.6	1.2	1.8	4.0	1.4	1.8	3.7	4.4	2.5	3.0	4.3	2.6
29..........	8.6	......	2.0	3.7	1.4	1.6	4.2	3.4	2.3	2.8	4.3	2.5
30..........	4.6	......	8.5	3.2	1.4	1.4	4.1	2.0	2.1	2.6	3.9	2.4
31..........	3.9	......	11.4	......	1.4	...	4.2	2.3	......	2.4	......	2.4

Rating table for Coosa River at Rome, Ga., for 1897 and 1898.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
-0.15	990	2.5	3,760	5.1	8,445	7.7	13,515
0.0	1,070	2.6	3,910	5.2	8,640	7.8	13,710
0.1	1,140	2.7	4,060	5.3	8,835	7.9	13,905
0.2	1,210	2.8	4,220	5.4	9,030	8.0	14,100
0.3	1,280	2.9	4,380	5.5	9,225	8.1	14,295
0.4	1,360	3.0	4,540	5.6	9,420	8.2	14,490
0.5	1,440	3.1	4,700	5.7	9,615	8.3	14,685
0.6	1,520	3.2	4,860	5.8	9,810	8.4	14,880
0.7	1,610	3.3	5,020	5.9	10,005	8.5	15,075
0.8	1,700	3.4	5,180	6.0	10,200	8.6	15,270
0.9	1,800	3.5	5,340	6.1	10,395	8.7	15,465
1.0	1,900	3.6	5,520	6.2	10,590	8.8	15,660
1.1	2,000	3.7	5,715	6.3	10,785	8.9	15,855
1.2	2,110	3.8	5,910	6.4	10,980	9.0	16,050
1.3	2,220	3.9	6,105	6.5	11,175	10.0	18,000
1.4	2,330	4.0	6,300	6.6	11,370	11.0	19,950
1.5	2,450	4.1	6,495	6.7	11,565	12.0	21,900
1.6	2,570	4.2	6,690	6.8	11,760	13.0	23,850
1.7	2,690	4.3	6,885	6.9	11,955	14.0	25,800
1.8	2,810	4.4	7,080	7.0	12,150	15.0	27,750
1.9	2,930	4.5	7,275	7.1	12,345	16.0	29,700
2.0	3,060	4.6	7,470	7.2	12,540	17.0	31,650
2.1	3,190	4.7	7,665	7.3	12,735	18.0	33,600
2.2	3,320	4.8	7,860	7.4	12,930	20.0	37,500
2.3	3,460	4.9	8,055	7.5	13,125	22.0	41,400
2.4	3,610	5.0	8,250	7.6	13,320	24.0	45,300

NOTE.—This taoie applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made during 1899 by Max Hall and others:

January 25—Gage height, 3.80 feet; discharge, 6,540 second-feet.
January 25—Gage height, 3.60 feet; discharge, 5,932 second-feet.
May 19—Gage height, 2.75 feet; discharge, 4,394 second-feet.
June 16—Gage height, 2.40 feet; discharge, 3,352 second-feet.
August 4—Gage height, 1.45 feet; discharge, 2,835 second-feet.
October 13—Gage height, 0.60 foot; discharge, 1,769 second-feet.

Daily gage height, in feet, of Coosa River, at Rome, Georgia, for 1899.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1..........	3.00	6.90	19.70	13.20	4.00	3.00	1.70	2.20	3.40	0.40	0.7	1.1
2..........	3.40	7.80	15.00	10.60	3.70	2.60	1.50	1.90	2.00	.30	.6	1.1
3..........	3.00	6.00	8.60	7.90	3.70	2.60	1.00	1.70	1.60	.30	.5	1.5
4..........	2.70	9.20	6.60	7.20	3.50	2.00	.90	1.50	1.40	.30	.5	1.3
5..........	2.60	15.30	7.80	9.50	3.50	2.00	2.00	1.40	1.30	.30	.4	1.1
6..........	2.60	18.20	9.00	8.20	3.50	2.00	1.90	1.50	1.30	.50	.4	1.0
7..........	3.60	27.80	8.00	8.20	3.70	2.00	1.90	1.60	1.20	.70	.3	.9
8..........	5.90	24.00	6.80	15.00	3.70	1.90	3.00	1.50	1.00	.70	.3	.8
9..........	5.90	22.40	5.70	13.40	3.60	1.80	2.10	1.80	1.00	.80	.3	.8
10..........	4.90	21.00	5.40	11.20	3.50	1.80	1.90	1.60	1.00	.60	.3	.8
11..........	4.00	19.00	5.20	9.50	3.30	1.80	2.50	1.40	2.90	1.00	.3	.8
12..........	4.50	16.50	4.90	7.00	3.10	2.20	2.80	1.40	2.30	.90	.3	2.8
13..........	4.00	7.00	4.50	6.40	3.10	3.80	2.00	1.20	1.50	.70	.3	6.1
14..........	3.80	5.00	6.00	5.90	3.00	4.00	1.60	1.10	1.00	.70	.4	5.0
15..........	3.60	5.00	16.60	5.60	3.00	3.50	1.30	1.30	.90	.60	.4	3.2
16..........	3.60	5.50	27.70	5.40	2.90	2.50	1.80	1.90	.80	.60	.5	2.0
17..........	4.00	8.90	29.20	5.20	2.80	2.10	5.20	1.60	.60	.60	.9	1.8
18..........	4.20	9.50	25.80	4.80	2.80	2.00	4.20	1.40	.60	.60	.7	1.7
19..........	4.00	8.50	24.90	4.70	2.80	2.00	4.80	1.10	.60	.60	.5	1.3
20..........	3.70	7.70	26.20	4.60	2.80	2.00	8.80	.90	.70	.60	.5	1.6
21..........	3.30	6.80	24.60	4.30	2.60	1.80	12.80	.30	.70	.70	.5	2.0
22..........	3.20	6.90	23.00	4.10	2.60	2.20	7.90	.80	.60	.70	.4	2.0
23..........	3.10	7.30	22.60	4.00	2.40	1.70	4.80	.80	.60	.60	1.0	1.8
24..........	3.50	6.60	21.90	5.40	2.60	1.70	3.90	.70	.50	.50	2.1	7.2
25..........	3.80	5.80	18.00	7.40	2.50	1.70	2.60	.70	.50	.40	1.6	7.5
26..........	3.80	5.50	10.50	9.10	2.40	1.70	2.60	.70	.50	.40	2.5	5.0
27..........	3.30	19.10	7.70	6.70	2.20	2.10	3.80	2.50	.50	.40	3.0	3.5
28..........	3.00	23.40	6.80	5.50	2.20	1.90	3.00	2.50	.60	.40	2.2	3.0
29..........	3.00	......	8.80	4.80	2.00	1.90	2.40	2.50	.50	.40	1.9	3.0
30..........	2.90	......	9.30	4.20	2.00	1.80	1.40	2.00	.40	.50	1.4	3.4
31..........	4.40	......	10.20	......	3.30	....	1.20	2.50	......	.80	......	2.0

Rating table for Coosa River at Rome, Georgia, for 1899.

Gage height.	Discharge.	Gage height	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
1.0	2,030	8.1	14,941	15.9	30,619	23.0	44,890
1.1	2,124	8.2	15,142	16.0	30,820	23.1	45,091
1.2	2,218	9.0	16,750	16.1	31,021	23.2	45,292
1.3	2,312	9.1	16,951	16.2	31,222	23.3	45,493
1.4	2,406	9.2	17,152	16.3	31,423	23.4	45,694
1.5	2,500	9.3	17,353	16.4	31,624	23.5	45,895
1.6	2,620	9.4	17,554	16.5	31,825	23.6	46,096
1.7	2,740	9.5	17,755	16.6	32,026	23.7	46,297
1.8	2,860	9.6	17,956	16.7	32,227	23.8	46.498
1.9	2,980	9.7	18,157	16.8	32,428	23.9	46,699
2.0	3,100	9.8	18,358	16.9	32,629	24.0	46,900
2.1	3,260	9.9	18,559	17.0	32,830	24.1	47,101
2.2	3,420	10.0	18,760	17.1	33,031	24.2	47,302
2.3	3,580	10.1	18,961	17.2	33,232	24.3	47,503
2.4	3,740	10.2	19,162	17.3	33,433	24.4	47,704
2.5	3,900	10.3	19,363	17.4	33,634	24.5	47,905
2.6	4,060	10.4	19,564	17.5	33,835	24.6	48,106
2.7	4,220	10.5	19,765	17.6	34,036	24.7	48,307
2.8	4,380	10.6	19,966	17.7	34,237	24.8	48,508
2.9	4,540	10.7	20,167	17.8	34,438	24.9	48,709
3.0	4,700	10.8	20,368	17.9	34,639	25.0	48,910
3.1	4,900	10.9	20,569	18.0	34,840	25.1	49,111
3.2	5,100	11.0	20,770	18.1	35,041	25.2	49,312
3.3	5,300	11.1	20,971	18.2	35,242	25.3	49,513
3.4	5,500	11.2	21,172	18.3	35,443	25.4	49,714
3.5	5,700	11.3	21,373	18.4	35,644	25.5	49,915
3.6	5,900	11.4	21,574	18.5	35,845	25.6	50,116
3.7	6,100	11.5	21,775	18.6	36,046	25.7	50,317
3.8	6,300	11.6	21,976	18.7	36,247	25.8	50,518
3.9	6,500	11.7	22,177	18.8	36,448	25.9	50,719
4.0	6,700	11.8	22,378	18.9	36,649	26.0	50,920
4.1	6,901	11.9	22,579	19.0	36,850	26.1	51,121
4.2	7,102	12.0	22,780	19.1	37,051	26.2	51,322
4.3	7,303	12.1	22,981	19.2	37,252	26.3	51,523
4.4	7,504	12.2	23,182	19.3	37,453	26.4	51,724
4.5	7,705	12.3	23,383	19.4	37,654	26.5	51,925
4.6	7,906	12.4	23,584	19.5	37,855	26.6	52,126
4.7	8,107	12.5	23,785	19.6	38,056	26.7	52,327
4.8	8,308	12.6	23,986	19.7	38,257	26.8	52,528
4.9	8,509	12.7	24,187	19.8	38,458	26.9	52,729
5.0	8,710	12.8	24,388	19.9	38,659	27.0	52,930
5.1	8,911	12.9	24,589	20.0	38,860	27.1	53,131
5.2	9,112	13.0	24,790	20.1	39,061	27.2	53,332
5.3	9,313	13.1	24,991	20.2	39,262	27.3	53,533
5.4	9,514	13.2	25,192	20.3	39,463	27.4	53,734

Rating table for Coosa River at Rome, Ga., for 1899.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*		*Second ft.*	*Feet.*	*Second ft.*
5.5	9,715	13.3	25,393	20.4	39,664	27.5	53,935
5.6	9,916	13.4	25,594	20.5	39,865	27.6	54,136
5.7	10,117	13.5	25,795	20.6	40,066	27.7	54,337
5.8	10,318	13.6	25,996	20.7	40,267	27.8	54,538
5.9	10,519	13.7	26,197	20.8	40,468	27.9	54,739
6.0	10,720	13.8	26,398	20.9	40,669	28.0	54,940
6.1	10,921	13.9	26,599	21.0	40,870	28.1	55,141
6.2	11,122	14.0	26,800	21.1	41,071	28.2	55,342
6.3	11,323	14.1	27,001	21.2	41,272	28.3	55,543
6.4	11,524	14.2	27,202	21.3	41,473	28.4	55,744
6.5	11,725	14.3	27,403	21.4	41,674	28.5	55,945
6.6	11,926	14.4	27,604	21.5	41,875	28.6	56,146
6.7	12,127	14.5	27,805	21.6	42,076	28.7	56,347
6.8	12,328	14.6	28,006	21.7	42,277	28.8	56,548
6.9	12,529	14.7	28,207	21.8	42,478	28.9	56,749
7.0	12,730	14.8	28,408	21.9	42,679	29.0	56,950
7.1	12,931	14.9	28,609	22.0	42,880	29.1	57,151
7.2	13,132	15.0	28,810	22.1	43,081	29.2	57,352
7.3	13,333	15.1	29,011	22.2	43,282	29.3	57,553
7.4	13,534	15.2	29,212	22.3	43,483	29.4	57,754
7.5	13,735	15.3	29,413	22.4	43,684	29.5	57,955
7.6	13,936	15.4	29,614	22.5	43,885	29.6	58,156
7.7	14,137	15.5	29,815	22.6	44,086	29.7	58,357
7.8	14,338	15.6	30,016	22.7	44,287	29.8	58,558
7.9	14,539	15.7	30,217	22.8	44,488	29.9	58,759
8.0	14,740	15.8	30,418	22.9	44,689	30.0	58,960

The following discharge measurements were made during 1900 by Max Hall and others:

Feb. 21—Gage height, 4.80 feet; discharge, 8,115 second-feet.
May 19—Gage height, 2.30 feet; discharge, 4,496 second-feet.
Sept. 13—Gage height, 0.90 foot; discharge, 1,992 second-feet.
Dec. 8—Gage height, 3.73 feet; discharge, 6,066 second-feet.

Daily gage height, in feet, of Coosa River, at Rome, Georgia, for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	2.0	2.0	4.2	4.4	6.2	2.4	10.5	3.4	1.5	1.2	2.1	3.2
2	1.6	1.8	5.8	4.2	4.8	2.5	8.0	3.2	1.6	1.2	2.2	2.8
3	1.5	1.6	5.6	4.0	4.0	2.8	8.0	3.0	1.7	1.0	2.0	2.6
4	1.5	2.0	4.4	4.0	4.0	4.2	7.0	2.8	1.7	1.0	2.3	3.5
5	1.5	3.0	4.1	4.0	3.8	4.2	5.5	2.6	1.5	.9	2.3	7.4
6	1.5	3.8	3.8	4.0	3.7	4.2	4.2	2.5	1.6	.9	2.1	6.8
7	1.5	2.8	5.0	3.8	3.6	4.8	3.8	2.2	1.4	.9	2.1	5.2
8	1.5	2.4	8.2	3.8	3.4	13.0	3.8	2.2	1.0	3.8	2.0	3.8
9	1.5	4.0	15.0	3.6	3.0	12.6	4.0	2.0	1.0	5.9	1.9	3.6
10	1.5	6.9	13.4	3.5	3.0	8.0	4.9	2.0	.8	2.6	1.8	3.2
11	2.0	7.0	10.3	6.0	3.0	5.9	3.8	1.8	.8	2.0	1.8	2.8
12	7.0	6.4	7.5	11.0	3.0	5.0	3.4	1.8	.8	1.8	1.6	2.6
13	9.0	22.6	5.5	7.4	2.5	5.2	3.8	1.8	.8	2.5	1.5	2.6
14	7.2	27.2	4.8	5.5	2.4	5.3	3.4	1.7	.8	3.2	1.5	2.4
15	5.5	25.3	4.2	4.5	2.4	4.2	3.4	2.0	6.5	3.0	1.5	2.2
16	3.5	21.2	5.3	5.6	2.4	3.8	3.3	1.7	11.1	2.0	1.5	2.2
17	3.0	18.0	5.6	6.2	2.4	4.8	3.1	1.6	7.0	1.6	1.5	2.2
18	2.9	10.7	4.5	11.0	2.4	6.0	3.0	1.8	3.2	1.5	1.4	2.0
19	5.0	5.0	5.2	11.1	2.9	6.5	2.8	2.2	2.3	1.5	1.4	2.0
20	11.3	4.0	15.9	11.4	3.0	7.2	2.6	2.0	2.0	1.4	1.6	2.8
21	10.6	4.1	17.5	13.6	2.6	4.2	2.5	1.6	1.8	1.8	1.8	6.7
22	8.5	6.8	14.6	12.7	2.5	3.6	2.4	1.6	1.8	1.8	2.1	8.0
23	5.8	7.6	10.4	10.5	2.3	5.5	2.4	1.6	1.6	1.6	2.1	7.0
24	4.0	6.0	7.2	8.6	2.9	14.2	2.4	1.9	1.6	1.6	2.0	6.6
25	3.4	5.8	8.8	8.5	3.2	18.2	3.6	2.4	1.5	1.5	5.0	6.6
26	3.1	5.2	13.0	6.5	2.7	17.0	2.8	2.0	1.5	1.5	11.0	5.6
27	2.8	4.6	12.1	5.3	2.6	15.5	6.2	1.8	1.4	1.4	11.5	4.0
28	2.6	4.0	8.9	4.8	2.5	15.6	6.8	1.6	1.4	2.2	8.6	3.8
29	2.4	......	5.8	4.3	2.4	14.2	6.2	1.5	1.3	2.2	7.0	3.6
30	2.1	......	5.7	6.0	2.9	10.0	4.5	1.5	1.3	2.1	4.0	3.5
31	2.0	......	5.3	......	3.0	....	4.0	1.5	......	2.1	......	5.6

The following discharge measurements were made during 1901 by Max Hall and others:

Jan. 23—Gage height, 3.60 feet; discharge, 6,454 second-feet.
April 5—Gage height, 9.90 feet; discharge, 16,692 second-feet.
June 22—Gage height, 3.70 feet; discharge, 6,030 second-feet.
Oct. 15—Gage height, 3.15 feet; discharge, 5,388 second-feet.

Daily gage height of Coosa River at Rome, Georgia, for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	7.4	6.4	3.0	8.8	4.0	10.6	3.6	1.8	6.4	2.6	1.2	1.3
2..........	6.4	5.8	3.0	8.6	3.8	7.6	3.0	1.8	5.8	2.6	1.2	1.3
3..........	5.2	5.5	3.0	13.0	3.8	5.6	3.0	1.8	3.7	3.2	1.2	1.3
4..........	4.2	15.8	3.0	13.0	3.8	6.4	2.6	1.6	3.4	3.0	1.2	1.5
5..........	4.0	18.5	3.0	10.0	3.6	5.0	2.4	1.6	3.0	2.8	1.2	2.0
6..........	3.8	13.8	3.0	7.9	3.5	4.0	2.2	2.6	2.9	2.2	1.2	1.8
7..........	3.5	9.5	3.0	6.4	3.5	7.0	5.2	5.3	2.6	2.0	1.2	1.8
8..........	3.2	6.5	3.0	5.6	3.4	7.6	4.8	5.9	2.2	1.9	1.1	1.8
9..........	3.0	9.6	2.8	5.2	3.3	5.4	3.3	3.0	2.0	1.9	1.1	1.8
10..........	2.8	12.5	5.5	4.5	3.1	4.3	2.6	2.6	2.0	1.8	1.1	1.8
11..........	8.8	10.5	7.8	4.3	3.0	4.0	2.4	2.5	2.0	1.7	1.0	2.6
12..........	23.5	7.6	8.0	4.2	2.9	3.8	2.3	3.4	2.0	1.6	1.0	2.6
13..........	27.0	6.5	6.7	4.3	2.8	3.8	2.0	3.0	1.8	1.8	1.0	2.1
14..........	23.8	5.6	4.8	10.4	2.8	4.0	2.0	2.3	2.0	2.0	1.0	2.2
15..........	21.4	5.0	4.0	10.1	2.7	4.3	2.0	4.5	3.0	3.2	1.0	16.4
16..........	19.8	4.8	3.6	7.7	2.6	6.9	1.9	7.2	2.4	2.6	1.0	17.6
17..........	17.4	4.2	3.2	5.8	2.6	6.0	1.7	10.5	6.0	2.4	1.0	14.7
18..........	8.9	4.2	3.0	5.2	2.5	5.0	5.5	9.8	11.2	2.4	1.0	14.0
19..........	5.0	4.2	3.0	9.0	2.5	4.8	3.0	10.8	11.1	2.0	1.0	13.0
20..........	4.0	4.0	3.0	18.6	3.0	4.0	3.0	12.5	7.0	1.8	1.0	5.6
21..........	3.8	3.8	3.0	17.2	10.0	3.8	2.4	10.8	3.9	1.8	1.6	3.0
22..........	3.8	3.7	3.0	15.5	23.6	3.6	2. 4	14.5	3.7	1.6	1.2	2.0
23..........	3.8	3.6	3.0	14.6	26.4	3.6	2.4	20.8	3.3	1.6	1.4	2.0
24..........	3.8	3.6	3.6	12.7	21.8	3.6	2.0	23.2	2.8	1.6	1.4	3.6
25..........	6.7	3.5	3.6	6.8	18.9	2.7	2.0	18.3	2.6	1.6	1.3	4.0
26..........	6.6	3.2	22.0	5.6	16.5	2.7	1.9	13.1	2.5	1.4	1.3	3.7
27..........	5.4	3.2	27.0	4.8	11.1	3.2	1.7	6.6	2.3	1.3	1.3	5.7
28..........	5.2	3.0	24.5	4.4	5.5	3.0	2.8	8.8	2.0	1.3	1.3	6.0
29..........	5.0	......	21.3	4.2	4.9	3.6	1.9	7.5	2.0	1.3	1.3	21.5
30..........	4.6	......	19.2	4.1	4.7	3.6	1.9	6.2	2.5	1.3	1.3	29.8
31..........	6.8	......	16.1	......	5.4	...	1.6	5.6	......	1.2	......	32.6

Rating table for Coosa River at Rome, Ga., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet*	*Second ft.*
0.8	1,930	1.6	2,850	2.4	4,000	3.2	5,230
0.9	2,020	1.7	2,985	2.5	4,150	3.3	5,405
1.0	2,110	1.8	3,120	2.6	4,300	3.4	5,580
1.1	2,230	1.9	3,260	2.7	4,450	3.5	5,755
1.2	2,350	2.0	3,400	2.8	4,600	*3.6	5,930
1.3	2,475	2.1	3,550	2.9	4,750		
1.4	2,600	2.2	3,700	3.0	4,900		
1.5	2,725	2.3	3,850	3.1	5,065		

***Above 3.6 ft. gage height, the rating for 1900-1901 is the same as for 1899.**

Estimated monthly discharge of Coosa River at Rome, Ga.
[Drainage area, 4,006 square miles.]

Month.	Discharge in second-feet.			Total in acre-ft.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-ft. per sq. mile.
1897.						
January	17,025	1,800	4,820	296,372	1.38	1.20
February	20,925	4,220	10,100	560,926	2.62	2.52
March	44,910	4,700	22,537	1,385,755	6.49	5.63
April	35,150	4,860	12,304	732,137	3.43	3.07
May	8,250	2,930	4,421	271,838	1.27	1.10
June	4,540	1,900	2,884	171,610	0.80	0.72
July	23,460	1,800	5,184	318,754	1.50	1.30
August	4,860	1,360	2,256	138,717	0.64	0.56
September	1,900	900	1,106	65,811	0.31	0.28
October	2,570	1,010	1,518	93,339	0.44	0.38
November	2,000	1,440	1,626	96,754	0.46	0.41
December	9,810	1,900	4,086	251,240	1.18	1.02
1898.						
January	26,970	2,220	7,272	447,138	2.10	1.82
February	5,520	2,110	2,705	150,228	0.71	0.68
March	20,730	2,110	4,384	269,563	1.27	1.10
April	32,040	4,540	9,430	561,123	2.63	2.36
May	4,220	2,330	2,778	170,814	0.79	0.69
June	5,520	2,110	2,866	170,538	0.80	0.72
July	6,690	1,900	3,670	225,661	10.59	9.17
August	17,805	2,930	6,079	373,786	1.75	1.52
September	45,885	3,060	12,114	720,832	2.26	3.03
October	44,910	3,060	11,830	727,403	3.41	2.96
November	12,150	3,060	5,213	310,194	1.45	1.30
December	8,250	3,610	4,996	307,194	1.44	1.25
1899.						
January	10,519	4,060	6,092	374,582	1.75	1.52
February	54,538	8,710	22,536	1,251,586	5.85	5.62
March	57,352	7,705	26,314	1,617,985	7.57	6.57
April	28,810	6,700	13,333	793,369	3.72	3.33
May	6,700	3,100	4,783	294,095	1.37	1.19
June	6,700	2,740	3,489	207,610	0.97	0.87
July	24,388	1,950	5,499	338,120	1.58	1.37
August	3,900	1,790	2,595	159,560	0.75	0.65
September	5,500	1,550	2,219	132,040	0.61	0.55
October	2,030	1,470	1,684	103,545	0.48	0.42
November	4,700	1,470	2,009	119,544	0.56	0.50
December	13,735	1,870	4,314	265.258	1.25	1.08

Estimated monthly discharge of Coosa River at Rome, Georgia.

[Drainage area, 4,006 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean		Depth in inches.	Second-ft. per sq. mile.
1900.						
January	21,373	2,725	6,854	421,436	1.97	1.71
February	53,332	2,850	14,736	818,396	3.83	3.68
March	33,835	6,300	14,714	904,728	4.33	3.67
April	25,996	5,755	12,050	717,025	3.36	3.01
May	11,122	3,850	5,129	315,370	1.48	1.28
June	35,242	4,000	14,154	842,222	3.94	3.53
July	19,765	4,000	7,589	466,629	2.18	1.89
August	5,580	2,725	3,488	214,469	1.00	0.87
September	20,971	1,930	3,960	235,636	1.10	0.99
October	10,519	2,010	3,408	209,550	0.98	0.85
November	21,775	2,600	5,438	323,583	1.52	1.36
December	14,740	3,400	7,096	436,316	2.04	1.77
The year	53,332	1,930	8,218	5,905,360	27.73	2.05

Estimated monthly discharge of Coosa River at Rome, Ga.

[Drainage area, 4,006 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1901.					
January	52,930	4,600	15,450	4.45	3.86
February	35,845	4,900	12,186	3.17	3.04
March	52,930	4,600	13,406	3.85	3.34
April	36,046	6,901	15,578	4.33	3.88
May	51,724	4,150	12,533	3.60	3.12
June	19,966	4,450	8,316	2.32	2.08
July	9,715	2,850	4,441	1.27	1.10
August	45,292	2,850	13,780	3.97	3.44
September	21,172	3,120	6,389	1.77	1.59
October	5,230	2,350	3,414	.98	.85
November	2,850	2,110	2,316	.65	.58
December	64,186	2,475	13,428	3.86	3.35
The year	64,186	2,110	10,103	34.22	2.52

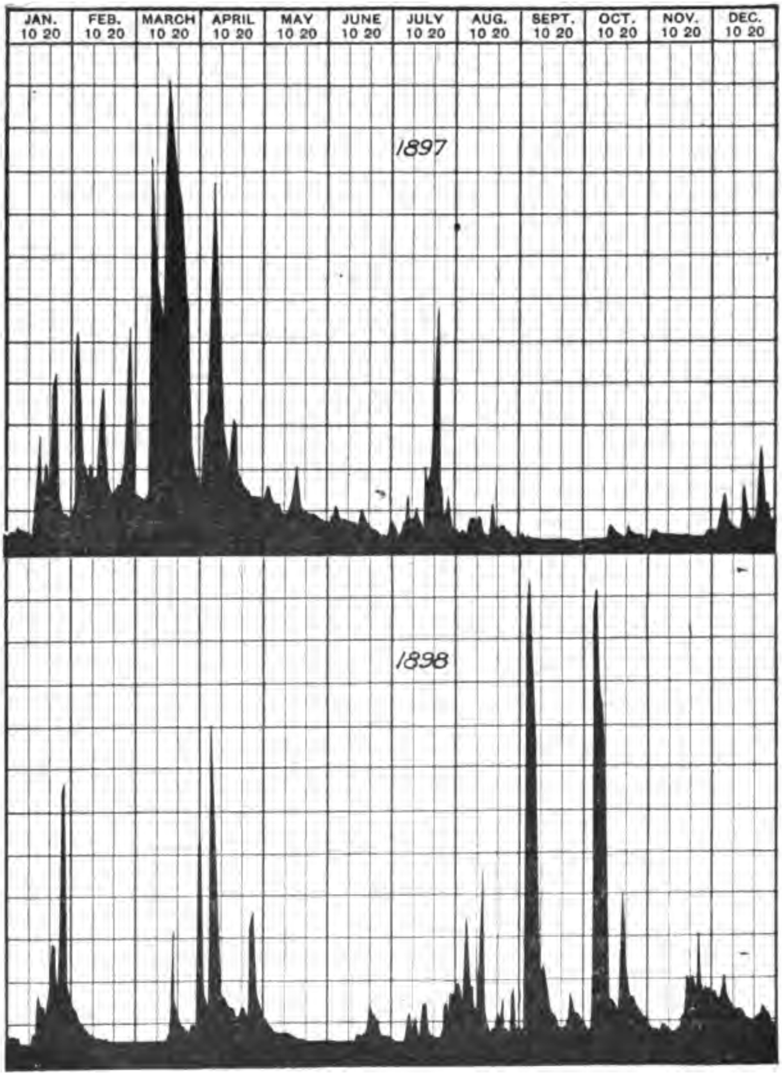

Fig. 12—Discharge of Coosa River at Rome, Ga., 1897 and 1898.

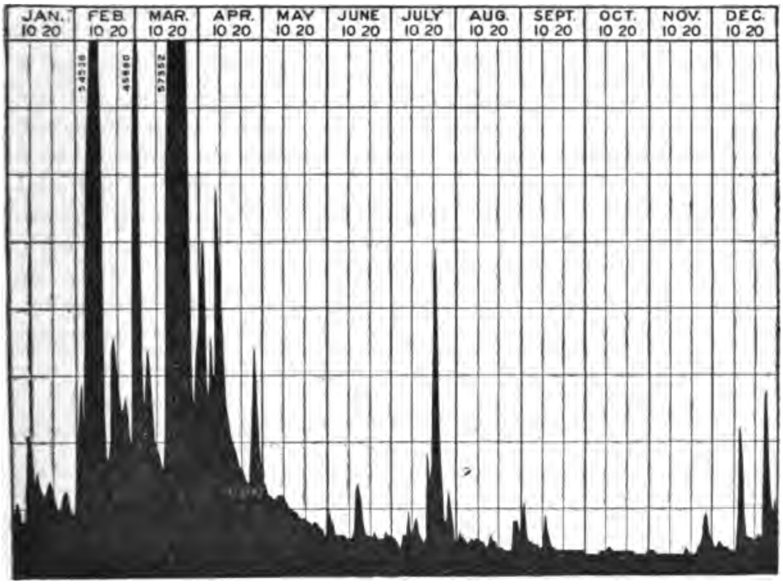

Fig. 13—Discharge of Coosa River at Rome, Ga., 1899.

Minimum monthly discharge of Coosa River at Rome, Ga., with corresponding net horse-power per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.

	1899			1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot fall.	No. of days duration of minimum.
January ..	4,060	369	2	2,725	248	8	4,600	418	1
February .	8,710	792	2	2,850	259	1	4,900	445	1
March	7,705	700	1	6,300	573	1	4,600	418	1
April	6,700	609	1	5,755	523	1	6,901	627	1
May	3,100	282	2	3,850	350	1	4,150	377	2
June	2,740	249	4	4,000	364	1	4,450	405	2
July	1,950	177	1	4,000	364	3	2,850	259	1
August ...	1,790	163	3	2,725	248	3	2,850	259	2
September .	1,550	141	1	1,930	175	5	3,120	284	1
October ...	1,470	134	4	2,010	183	3	2,350	214	1
November .	1,470	134	7	2,600	236	2	2,110	192	10
December ..	1,870	170	4	3,400	309	2	2,475	225	3

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

3. TALLADEGA CREEK AT NOTTINGHAM, ALABAMA.

This station is located on the Southern railroad bridge a fourth of a mile from the depot at Nottinghom, Ala, and one mile north of Alpine, Ala. The gage, which is graduated to feet and tenths and is 20 feet long, is fastened vertically to a tree on right bank about 50 feet above the bridge. The initial point of sounding is end of iron bridge right bank up stream. The bench mark is top rail on the upstream side of the bridge, and is 24.13 feet above gage datum. The station is a good one and is free from piers. The observer is R. M. McClatchy, station agent at Nottingham. During 1900 the following measurements were made by James R. Hall:

August 16—Gage height, 1.10 feet; discharge, 102 second-feet.
November 29—Gage height, 1.70 feet; discharge, 240 second-feet.

Daily gage height in feet of Talladega Creek at Nottingham, Ala., for 1900.

Day.	Aug.	Sept.	Oct.	Nov.	Dec.	Day.	Aug.	Sept.	Oct.	Nov.	Dec.
1	......	1.2	1.0	1.3	1.6	17	1.2	2.3	1.1	1.2	1.5
2	......	2.0	1.0	1.3	1.4	18	1.2	1.7	1.1	1.2	1.5
3	......	1.3	1.0	2.3	1.4	19	1.1	1.6	1.1	1.2	1.[illegible]
4	......	1.1	1.0	2.1	1.8	20	1.1	1.5	1.0	1.5	2.7
5	......	1.0	1.2	1.7	1.7	21	1.1	1.3	1.2	2.2	3.0
6	......	1.0	1.3	1.5	1.6	22	1.1	1.2	1.4	1.9	2.6
7	......	1.0	1.3	1.4	1.5	23	1.1	1.2	1.6	1.8	4.0
8	......	.9	1.4	1.4	1.5	24	1.0	1.2	2.9	1.6	2.5
9	......	11.0	1.3	1.3	1.4	25	.9	1.2	3.5	3.9	2.1
10	......	8.0	1.3	1.3	1.3	26	1.0	1.2	3.0	3.8	2.0
11	......	10.3	1.3	1.3	1.3	27	1.1	1.2	2.6	3.4	1.8
12	......	8.0	1.5	1.3	1.3	28	1.2	1.2	1.4	2.0	1.7
13	......	8.3	1.4	1.2	1.6	29	1.0	1.1	1.3	1.8	1.6
14	......	9.3	1.3	1.2	1.8	30	1.0	1.1	1.3	1.7	1.9
15	......	9.3	1.2	1.2	1.7	31	1.6	......	1.3	......	5.1
16	1.1	3.9	1.2	1.2	1.6						

The following discharge measurements were made during 1901 by Max Hall and others:

April 5—Gage height, 3.0 feet; discharge, 526 second-feet.
October 22—Gage height, 1.0 feet; discharge, 90 second-feet.

Daily gage height in feet of Talladega Creek at Nottingham, Ala., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	3.2	2.3	2.0	3.4	2.2	2.0	1.5	1.1	1.2	1.1	1.0	1.0
2	2.8	2.1	2.0	5.9	2.2	2.0	1.4	1.0	1.2	2.8	1.0	1.4
3	3.2	3.8	2.0	4.5	2.1	2.0	1.3	1.0	1.2	2.5	1.0	1.3
4	2.7	8.0	2.0	3.4	2.0	1.8	1.3	1.0	1.1	1.5	1.0	1.2
5	2.4	3.9	1.8	3.0	2.0	1.7	1.3	1.0	1.1	1.3	1.0	1.2
6	2.2	3.2	1.8	2.9	1.9	1.7	1.4	1.0	1.1	1.2	1.0	1.3
7	2.1	2.8	1.8	2.6	1.9	3.0	1.4	1.0	1.1	1.1	1.0	1.1
8	2.1	2.8	1.8	2.5	1.9	1.9	1.3	1.0	1.1	1.1	1.0	1.0
9	2.0	3.3	1.8	2.3	1.9	1.7	1.3	1.0	1.0	1.1	1.0	1.0
10	1.9	2.8	2.0	2.2	1.9	1.6	1.2	1.0	1.0	1.0	1.0	1.1
11	5.8	2.6	1.9	2.1	1.9	1.5	1.2	1.0	1.0	1.0	1.0	1.1
12	8.8	2.7	1.8	2.1	1.9	1.5	1.2	1.1	1.0	1.0	1.0	1.0
13	4.7	2.5	1.8	2.7	2.0	1.6	1.2	1.0	1.0	1.1	1.0	1.0
14	3.4	2.3	1.8	3.7	1.9	1.8	1.2	1.0	1.0	1.0	1.0	2.4
15	2.9	2.2	1.8	2.7	1.9	1.7	1.2	1.0	1.0	1.0	1.0	3.5
16	2.6	2.2	1.7	2.5	1.9	1.6	1.2	2.3	1.0	1.0	1.0	1.7
17	2.7	2.2	1.7	2.3	1.8	1.5	1.2	2.2	3.4	1.0	1.0	1.5
18	2.4	2.1	1.7	2.4	1.7	1.4	2.0	1.9	2.8	1.0	1.0	1.3
19	2.2	2.1	1.7	11.2	1.9	1.4	1.5	1.7	1.6	1.0	1.0	1.2
20	2.2	2.0	1.8	6.3	2.5	1.4	1.3	1.5	1.5	1.0	1.0	1.1
21	2.1	2.0	2.1	4.1	3.9	1.4	1.3	1.4	1.4	1.0	1.0	1.1
22	2.2	2.0	2.0	3.4	2.5	1.3	1.2	1.3	1.3	1.0	1.1	1.1
23	2.2	2.0	1.8	3.1	2.0	1.3	1.2	1.2	1.3	1.0	1.2	1.1
24	2.2	2.1	2.6	2.8	1.8	1.3	1.2	1.2	1.2	1.0	1.3	1.1
25	2.2	2.1	2.8	2.7	1.7	1.3	1.2	1.5	1.2	1.0	1.2	1.3
26	2.3	2.1	8.9	2.6	1.7	1.3	1.2	1.3	1.1	1.0	1.1	1.2
27	2.2	2.0	4.6	2.5	1.7	1.3	1.2	1.4	1.1	1.0	1.1	1.1
28	2.2	.20	3.3	2.4	1.7	1.3	1.2	1.5	1.1	1.0	1.0	1.2
29	2.2	......	2.8	2.3	1.7	1.3	1.2	1.4	1.1	1.0	1.0	8.4
30	2.6	......	2.9	2.2	1.7	1.4	1.2	1.3	1.1	1.0	1.0	7.5
31	2.5	......	5.5	......	2.2	...	1.2	1.2	......	1.0	......	3.5

Rating table for Talladega Creek at Nottingham, Ala., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
1.0	90	2.1	328	3.2	570	4.3	812
1.1	109	2.2	350	3.3	592	4.4	834
1.2	130	2.3	372	3.4	614	4.5	856
1.3	152	2.4	394	3.5	636	4.6	878
1.4	174	2.5	416	3.6	658	4.7	900
1.5	196	2.6	438	3.7	680	4.8	922
1.6	218	2.7	460	3.8	702	4.9	944
1.7	240	2.8	482	3.9	724	5.0	966
1.8	262	2.9	504	4.0	746		
1.9	284	3.0	526	4.1	768		
2.0	306	3.1	548	4.2	790		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Talladega Creek at Nottingham, Ala.

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1900.					
August 16-31	....	....	113	0.72	0.43
September	2,286	74	575	3.69	4.12
October	636	90	190	1.22	1.41
November	724	130	249	1.60	1.79
December	746	152	291	1.87	2.16
1901.					
January	1,802	284	485	3.11	3.59
February	1,626	306	449	2.88	3.00
March	1,824	240	405	2.60	3.00
April	2,330	328	591	3.79	4.23
May	724	240	306	1.96	2.26
June	526	152	218	1.40	1.56
July	196	130	149	.96	1.11
August	372	90	148	.95	1.10
September	614	90	148	.95	1.06
October	482	90	123	.79	.91
November	152	90	97	.62	.69
December	1,714	90	264	1.69	1.95
The year	2,330	90	282	1.81	24.46

Minimum monthly discharge of Talladega Creek at Nottingham, Ala., with corresponding net horse-power per foot of fall on a water-wheel realizing 80 *per cent. of the theoretical power.*

	1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January	.....	.....	....	284	26	1
February	.....	.....	....	306	28	6
March	.....	.....	....	240	22	4
April	.....	.....	....	328	30	2
May	.....	.....	....	240	22	7
June	.....	.....	....	152	14	8
July	.....	.....	....	130	12	18
August	66	6	1	90	8	13
September	74	6.7	1	90	8	8
October	90	8	5	90	8	21
November	130	12	7	90	8	24
December	152	14	3	90	8	5

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

4. ALABAMA RIVER AT SELMA, ALABAMA.

This station was originally established by the United States Engineer Corps; readings are now taken by the United States Weather Bureau. The gage, which is attached to the iron highway bridge, the floor of which is about 60 feet above low water, is in two sections. The lower section, which reads from —0.3 feet to +2.30 feet, is secured to the pile on the lower side of the cofferdam on the draw pier; the upper section, which reads from 2.30 feet to 48 feet, is spiked to the highway bridge. The bench mark, which is an iron bolt driven into the face of a rock bluff 182.3 feet from the first bridge pier, on the road ascending to the city, is 26 feet above the zero of the gage and 87.30 feet above mean sea level. The top of the coping stone of the pivot pier at the highway bridge to which gage is attached is 56 feet above the zero of the gage, and 117.30 feet above mean sea level. Graduations extend from —3.0 feet to +48 feet. No measurements of discharge were made here during 1899.

Daily gage height, in feet, of Alabama River at Selma, Ala., for 1899.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	6.2	10.8	35.8	23.8	13.9	4.5	2.5	11.1	3.7	—1.2	—0.2	4.8
2	6.2	17.0	36.8	24.3	11.5	4.0	2.5	9.9	4.3	—1.3	— .3	3.7
3	6.5	20.2	38.8	24.9	9.9	4.0	2.6	9.0	4.6	—1.3	— .5	3.0
4	6.2	24.0	37.7	24.1	9.8	4.0	2.6	6.7	4.8	—1.3	— .6	3.0
5	6.2	26.8	35.3	22.3	8.5	3.8	2.1	6.5	4.4	—1.1	— .7	2.8
6	5.8	27.2	32.6	20.9	8.1	3.9	1.6	5.8	4.4	—1.0	— .7	2.8
7	6.6	27.2	30.5	20.0	7.5	3.8	1.6	5.3	4.1	—1.6	— .8	1.7
8	8.3	29.8	27.5	19.8	7.4	3.7	1.5	4.7	3.9	— .5	— .8	1.7
9	9.7	32.2	23.4	23.3	7.3	3.3	1.4	4.5	3.6	— .4	— .8	1.3
10	11.6	33.9	19.7	25.6	7.3	3.1	1.3	3.7	.6	— .4	— .9	1.3
11	13.9	34.4	16.9	26.9	7.5	2.8	1.3	3.5	.4	— .5	— .9	1.4
12	14.8	33.9	15.0	26.6	7.2	2.3	1.2	3.0	.3	— .6	—1.0	4.0
13	21.2	32.0	13.9	25.1	6.8	2.6	1.5	2.9	.3	— .6	—1.1	10.4
14	21.9	30.0	16.2	22.6	6.5	2.4	1.2	2.7	.2	— .2	—1.2	16.6
15	19.8	28.0	16.8	19.5	6.3	2.4	1.1	2.6	.2	— .2	—1.2	17.8
16	18.0	26.5	19.4	16.3	6.2	2.3	1.0	2.6	.1	— .2	—1.3	16.3
17	17.5	26.8	21.4	14.0	6.1	2.8	1.0	2.6	.6	— .3	—1.3	13.4
18	17.2	24.0	27.7	13.0	5.6	3.4	.7	3.6	1.3	— .5	—1.3	9.9
19	17.0	22.3	31.6	12.0	5.4	3.9	.6	4.1	1.0	— .7	—1.2	8.4
20	15.8	19.9	33.5	11.2	5.0	3.9	.6	4.3	.9	— .6	—1.0	3.8
21	14.2	19.9	34.7	10.5	4.8	3.1	1.0	3.6	.6	— .7	—1.0	3.8
22	12.6	19.5	34.8	10.4	4.5	2.8	1.6	3.5	— .6	— .8	— .6	3.4
23	10.2	18.8	34.2	10.2	4.4	1.6	5.5	3.4	— .7	— .2	— .6	3.4
24	10.3	17.8	33.4	10.1	4.8	1.4	10.7	3.1	— .8	.0	— .3	3.8
25	9.4	17.3	31.1	12.4	5.0	1.4	14.8	3.6	—1.0	.0	.1	7.6
26	9.0	16.4	32.6	13.5	6.0	1.6	17.0	4.2	—1.0	— .5	.2	12.2
27	8.9	20.3	31.8	16.3	6.1	1.7	17.0	3.9	—1.0	— .5	.9	13.5
28	8.6	31.2	30.5	17.9	5.2	2.0	14.9	3.6	—1.0	— .6	3.2	13.7
29	8.6	......	29.3	17.7	4.5	2.2	13.1	4.3	—1.1	— .6	1.6	12.8
30	9.0	......	27.8	16.1	4.3	2.4	12.8	4.6	—1.1	— .6	4.8	11.4
31	9.6	......	26.3	......	4.2	...	11.9	3.8	......	— .4	......	8.3

During 1900 the following measurements were made:

April 14—Gage height, 23.60 feet; discharge 66,607 second-feet.
May 26—Gage height, 6.10 feet; discharge, 17,049 second-feet.
August 24—Gage height, 3.10 feet; discharge, 9,879 second-feet.

Daily gage height, in feet, of Alabama River at Selma, Ala., for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	7.2	4.8	17.2	19.8	15.4	4.8	34.8	14.0	3.9	0.8	2.0	16.0
2..........	6.6	3.6	19.7	16.8	13.9	4.6	33.0	13.0	3.9	.7	2.0	14.0
3..........	4.3	3.5	22.2	14.0	13.0	4.4	29.8	11.0	3.8	.6	4.0	11.0
4..........	3.3	3.9	22.0	12.0	12.0	4.2	26.5	9.0	4.5	.6	9.0	9.0
5..........	3.0	4.7	20.6	10.9	11.8	5.6	23.5	7.0	5.4	.5	14.0	8.0
6..........	3.0	6.2	17.8	8.0	10.2	5.1	20.2	6.0	5.0	1.0	13.5	7.5
7..........	3.0	8.2	15.0	7.8	9.6	4.6	17.0	5.5	4.5	1.8	9.4	7.0
8..........	3.0	8.4	13.9	8.9	8.8	4.2	14.0	5.0	4.1	2.5	6.3	7.0
9..........	2.7	8.5	14.9	9.6	8.0	6.8	11.5	4.8	3.3	4.0	4.0	9.0
10..........	2.7	10.7	18.8	9.5	7.8	11.6	10.0	4.5	1.8	4.2	2.0	9.4
11..........	3.3	16.0	20.9	9.8	7.5	13.5	9.8	3.2	1.0	2.0	2.0	6.0
12..........	7.7	22.2	22.2	12.0	7.3	14.0	10.2	3.0	.7	2.0	1.9	5.0
13..........	12.4	29.9	22.0	17.7	7.0	13.9	10.0	2.8	.6	2.5	1.6	2.0
14..........	13.5	38.6	19.9	23.4	6.6	12.8	9.9	2.5	1.0	4.3	1.6	3.2
15..........	14.7	44.0	19.0	25.5	6.4	11.0	9.9	2.5	1.6	6.7	1.0	9.0
16..........	14.0	47.0	16.9	25.0	6.0	9.0	10.0	2.4	11.0	6.0	1.0	11.0
17..........	13.2	48.0	15.3	22.5	5.7	8.9	9.9	2.8	18.0	5.2	1.0	11.0
18..........	12.0	47.9	13.9	23.5	5.5	8.8	9.0	2.7	19.0	2.5	1.0	10.0
19..........	11.1	47.0	14.3	29.0	5.2	8.6	7.0	2.7	19.4	1.0	1.0	6.0
20..........	11.1	44.1	14.6	34.8	5.1	10.0	7.0	2.5	16.0	1.0	1.9	5.1
21..........	13.4	41.6	18.8	39.0	5.0	10.9	6.5	2.3	12.5	.9	1.0	9.0
22..........	16.9	36.9	23.0	39.8	5.0	12.0	6.5	2.6	10.0	1.0	1.6	14.5
23..........	18.5	33.2	25.5	41.0	4.8	12.9	6.3	3.6	6.0	1.5	6.0	17.0
24..........	18.3	22.6	29.0	40.0	5.5	14.0	6.0	3.8	3.0	6.0	9.0	17.2
25..........	17.0	22.6	30.2	38.5	6.1	17.6	5.8	4.0	1.9	11.5	9.8	17.6
26..........	14.7	21.1	32.7	35.8	6.2	24.5	5.0	3.5	1.6	12.0	9.9	18.0
27..........	13.0	19.0	33.3	32.7	6.6	29.0	4.5	3.5	1.0	11.5	13.0	17.0
28..........	11.2	16.9	32.5	28.5	6.8	32.0	4.4	3.4	1.0	12.3	16.0	14.5
29..........	8.4	......	30.5	23.0	6.0	33.5	7.5	3.5	.9	13.0	16.8	12.9
30..........	6.5	......	27.7	18.0	5.5	35.0	8.0	4.0	.8	11.0	17.0	11.2
31..........	4.8	......	24.4	......	5.0	....	11.8	4.2	......	5.0	......	11.0

List of Discharge Measurements made on Alabama River at Selma, Alabama, in 1901.

Date, 1901.	Hydrographer.	Gage height, ft	Dischg. sec.-ft.
March 14.	Max Hall	14.20	35,518
April 25..	J. R. Hall	34.00	90,332
August 9..	K. T. Thomas	4.35	12,519
October 30	Max Hall	1.10	7,710

Daily gage height, in feet, of Alabama River at Selma, Ala., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	16.0	13.0	11.3	35.6	12.0	19.0	1.0	2.8	17.0	4.3	1.4	1.8
2	21.0	13.0	9.8	36.5	10.4	17.0	2.0	2.6	13.8	4.3	1.4	1.8
3	24.0	13.6	9.5	37.4	10.0	16.5	2.4	2.6	10.6	5.0	1.4	1.9
4	24.6	17.0	9.3	38.5	9.6	18.5	6.6	2.8	8.8	7.4	1.5	2.2
5	24.0	24.9	9.6	38.4	8.2	19.0	6.0	3.0	8.0	7.9	1.5	2.3
6	23.0	30.1	9.6	37.2	7.0	19.8	5.6	2.8	7.4	6.4	1.4	2.3
7	18.0	33.0	9.4	35.5	7.0	18.5	5.6	6.6	6.0	5.8	1.6	2.4
8	15.0	35.1	8.0	33.0	6.8	17.4	5.5	4.6	5.2	5.0	1.6	2.1
9	13.3	35.6	7.7	28.0	6.4	16.1	5.5	4.2	4.4	4.3	1.5	2.0
10	10.0	35.7	7.9	22.6	6.0	14.8	5.5	3.4	4.4	3.4	1.5	2.2
11	8.1	33.0	9.0	17.4	5.0	12.0	5.2	4.0	3.6	2.9	1.5	2.4
12	16.5	31.4	10.2	14.0	5.0	11.0	5.2	5.3	3.4	2.8	1.5	2.4
13	28.0	31.2	12.0	12.0	4.8	9.5	5.1	6.2	3.2	2.6	1.4	2.4
14	34.0	27.0	14.1	11.8	4.5	8.0	4.4	4.4	3.7	2.5	1.4	2.6
15	38.0	26.0	15.4	12.0	4.0	7.6	3.7	3.8	4.3	2.2	1.4	5.0
16	39.5	20.6	15.0	15.0	3.8	7.0	3.7	6.0	4.0	2.5	1.3	10.0
17	40.0	16.9	14.8	16.5	3.4	6.1	3.5	7.4	5.0	2.5	1.3	18.0
18	39.0	14.6	12.0	17.3	3.2	6.0	4.3	11.0	5.0	2.4	1.3	21.6
19	37.5	13.1	11.1	22.0	3.0	5.0	6.3	12.0	5.5	2.0	1.4	22.0
20	35.0	12.6	10.5	28.6	3.0	4.1	7.3	16.0	9.5	2.3	1.6	21.5
21	32.4	12.0	11.0	35.0	3.5	3.4	6.0	17.6	11.4	2.5	1.8	18.7
22	29.0	11.8	11.9	38.0	4.7	3.0	5.5	18.8	11.5	2.5	1.8	15.0
23	24.0	11.7	12.2	39.0	9.4	3.0	5.4	20.0	11.2	2.2	1.8	14.2
24	22.0	11.6	13.0	38.0	17.0	2.6	5.4	20.9	10.0	2.0	1.8	12.0
25	14.0	11.2	14.7	35.8	19.0	2.2	4.4	22.8	7.5	2.0	1.9	11.0
26	12.8	11.5	17.0	31.9	20.0	2.0	4.0	24.6	6.0	2.0	1.9	7.1
27	12.8	11.4	22.5	28.0	20.9	1.5	4.0	24.8	4.4	1.8	2.0	6.2
28	12.7	11.3	27.6	24.2	22.0	1.3	3.6	22.9	4.0	1.6	2.0	6.0
29	12.7	......	31.0	19.5	21.8	1.2	2.9	21.0	4.0	1.5	2.0	11.0
30	13.0	......	33.0	15.0	20.7	1.2	2.9	20.6	4.2	1.3	1.8	23.0
31	13.0	......	34.5	......	19.5	...	2.8	19.5	......	1.3	......	35.0

Rating table for Alabama River at Selma, Ala., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
0.0	6,700	7.6	21,116	15.2	41,332	22.8	61,548
0.1	6,770	7.7	21,382	15.3	41,598	22.9	61,814
0.2	6,845	7.8	21,648	15.4	41,864	23.0	62,080
0.3	6,925	7.9	21,914	15.5	42,130	23.1	62,346
0.4	7,010	8.0	22,180	15.6	42,396	23.2	62,612
0.5	7,100	8.1	22,446	15.7	42,662	23.3	62,878
0.6	7,184	8.2	22,712	15.8	42,928	23.4	63,144
0.7	7,282	8.3	22,978	15.9	43,194	23.5	63,410
0.8	7,384	8.4	23,244	16.0	43,460	23.6	63,676
0.9	7,488	8.5	23,510	16.1	43,726	23.7	63,942
1.0	7,596	8.6	23,776	16.2	43,992	23.8	64,208
1.1	7,706	8.7	24,042	16.3	44,258	23.9	64,474
1.2	7,818	8.8	24,308	16.4	44,524	24.0	64,740
1.3	7,931	8.9	24,574	16.5	44,790	24.1	65,006
1.4	8,045	9.0	24,840	16.6	44,056	24.2	65,272
1.5	8,160	9.0	25,106	16.7	45,322	24.3	65,538
1.6	8,270	9.2	25,372	16.8	45,588	24.4	65,804
1.7	8,393	9.3	25,638	16.9	45,854	24.5	66,070
1.8	8,511	9.4	25,904	17.0	46,120	24.6	66,336
1.9	8,630	9.5	26,170	17.1	46,386	24.7	66,602
2.0	8,750	9.6	26,436	17.2	46,652	24.8	66,868
2.1	8,872	9.7	26,702	17.3	46,918	24.9	67,134
2.2	8,996	9.8	26,968	17.4	47,184	25.0	67,400
2.3	9,124	9.9	27,234	17.5	47,450	15.1	67,666
2.4	9,256	10.0	27,500	17.6	47,716	25.2	67,932
2.5	9,392	10.1	27,760	17.7	47,982	25.3	68,198
2.6	9,532	10.2	28,032	17.8	48,248	25.4	68,464
2.7	9,676	10.3	28,290	17.9	48,514	25.5	68,730
2.8	9,822	10.4	28,564	18.0	48,780	25.6	68,996
2.9	9,970	10.5	28,830	18.1	49,046	25.7	69,262
3.0	10,120	10.6	29,096	18.2	49,312	25.8	69,528
3.1	10,272	10.7	29,362	18.3	49,578	25.9	69,794
3.2	10,428	10.8	29,628	18.4	49,844	26.0	70,060
3.3	10,588	10.9	29,894	18.5	50,110	26.1	70,326
3.4	10,752	11.0	30,160	18.6	50,376	26.2	70,592
3.5	10,920	11.1	30,426	18.7	50,642	26.3	70,858
3.6	11,092	11.2	30,692	18.8	50,908	26.4	71,124
3.7	11,268	11.3	30,958	18.9	51,174	26.5	71,390
3.8	11,448	11.4	31,224	19.0	51,440	26.6	71,656
3.9	11,632	11.5	31,490	19.1	51,706	26.7	71,922
4.0	11,820	11.6	31,756	19.2	51,972	26.8	72,188
4.1	12,015	11.7	32,022	19.3	52,238	26.9	72,454
4.2	12,220	11.8	32,228	19.4	52,504	27.0	72,720
4.3	12,435	11.9	32,556	19.5	52,770	27.1	72,986
4.4	12,660	12.0	32,820	19.6	53,036	27.2	73,252
4.5	12,900	12.1	33,086	19.7	53,302	27.3	73,518

Rating table for Alabama River at Selma, Ala., for 1900 and 1901.
Continued.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet*	*Second ft.*
4.6	13,150	12.2	33,352	19.8	53,568	27.4	73,784
4.7	13,405	12.3	33,618	19.9	53,884	27.5	74,050
4.8	13,668	12.4	33,884	20.0	54,100	27.6	74,316
4.9	13,934	12.5	34,150	20.1	54,366	27.7	74,582
5.0	14,200	12.6	34,416	20.2	54,632	27.8	74,848
5.1	14,466	127.	34,682	20.3	54,898	27.9	75,114
5.2	14,732	12.8	34,948	20.4	55,164	28.0	75,380
5.3	14,998	12.9	35,214	20.5	55,430	28.1	75,646
5.4	15,264	13.0	35,480	20.6	55,696	28.2	75,912
5.5	15,530	13.1	35,746	20.7	55,962	28.3	76,178
5.6	15,796	13.2	36,012	20.8	56,228	28.4	76,444
5.7	16,062	13.3	36,278	20.9	56,494	28.5	76,710
5.8	16,328	13.4	36,544	21.0	56,760	28.6	76,976
5.9	16,594	13.5	36,810	21.1	57,026	28.7	77,242
6.0	16,860	13.6	37,076	21.2	57,292	28.8	77,508
6.1	17,126	13.7	37,342	21.3	57,558	28.9	77,744
6.2	17,392	13.8	37,608	21.4	57,824	29.0	78,040
6.3	17,658	13.9	37,874	21.5	58,090	29.1	78,306
6.4	17,924	14.0	38,140	21.6	58,356	29.2	78,572
6.5	18,190	14.1	38,406	21.7	58,622	29.3	78,838
6.6	18,456	14.2	38,672	21.8	58,888	29.4	79,104
6.7	18,722	14.3	38,838	21.9	59,154	29.5	79,370
6.8	18,988	14.4	39,104	22.0	59,420	29.6	79,636
6.9	19,254	14.5	39,370	22.1	59,686	29.7	79,902
7.0	19,520	14.6	39,676	22.2	59,952	29.8	80,168
7.1	19,786	14.7	40,002	22.3	60,218	29.9	80,434
7.2	20,052	14.8	40,268	22.4	60,484	30.0	80,700
7.3	20,318	14.9	40,534	22.5	60,750		
7.4	20,584	15.0	40,800	22.6	61,016		
7.5	20,850	15.1	41,066	22.7	61,282		

NOTE—This table applied to the foregoing "daily gage heights" gives cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Alabama River at Selma, Ala.
[Drainage area, 13,500 square miles.]

Month.	Discharge in second-feet			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second-feet per square mile.
1900.					
January	50,110	9,676	26,495	1.96	2.26
February	128,540	10,920	63,763	4.72	4.91
March	89,478	37,874	58,272	4.32	4.98
April	109,960	21,648	60,909	4.51	5.03
May	41,864	13,668	21,090	1.56	1.80
June	94,000	12,220	35,288	2.61	2.91
July	93,468	12,660	33,964	2.52	2.90
August	38,140	9,124	14,156	1.05	1.21
September	52,504	7,189	17,366	1.29	1.44
October	35,480	7,097	14,492	1.07	1.23
November	46,120	7,596	18,506	1.37	1.53
December	48,780	8,750	28,989	2.15	2.48
The year	128,540	7,097	33,772	2.34	32.68
1901.					
January	107,300	22,446	61,213	4.53	5.22
February	95,862	30,692	55,037	4.08	4.25
March	92,670	21,382	39,017	2.89	3.33
April	104,640	32,288	73,048	5.41	6.04
May	59,420	10,120	26,966	2.00	2.31
June	53,568	7,818	26,030	1.93	2.15
July	21,318	7,596	13,536	1.00	1.15
August	66,868	9,532	30,853	2.29	2.64
September	46,120	10,428	19,394	1.44	1.61
October	21,914	7,931	11,022	.82	.95
November	8,750	7,931	8,266	.61	.68
December	94,000	8,511	26,638	1.97	2.27
The year	107,300	7,596	32,585	2.47	32.60

Minimum monthly discharge of the Alabama River at Selma, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.

[Drainage area, 15,400 square miles.]

	1899.			1900.			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot fall.	No. of days duration of minimum.
January	16,328	1,484	1	9,676	880	2	22,446	2,041	1
February ...	29,628	2,693	1	10,920	993	1	30,692	2,790	1
March	37,874	3,443	1	37,874	3,443	2	21,382	1,944	1
April	27,760	2,524	1	21,648	1,968	1	32,288	2,935	1
May	12,220	1,111	1	13,668	1,243	1	10,120	920	2
June	8,045	731	2	12,220	1,111	2	7,818	711	2
July	7,184	653	2	12,660	1,151	1	7,596	691	1
August	9,532	867	3	9,124	829	1	9,532	867	2
September ..	5,800	527	2	7,189	653	1	10,428	948	1
October	5,400	491	1	7,100	645	1	7,931	721	2
November ..	5,700	518	3	7,596	691	7	7,931	721	3
December ..	7,931	721	2	8,750	795	1	8,511	774	2

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

5. MISCELLANEOUS DISCHARGE MEASUREMENTS

Made by B. M. Hall, and Assistants, on Tributaries of Coosa River.

1898.

May 26—Choccolocco Creek, Eureka; discharge, 171 second-feet; low water.

1900.

March 15—Talladega Creek, Kymulga postoffice; discharge, 107 second-feet; medium.

March 16—Tallassahatchee Creek, in Talladega county, Childersburg; discharge, 102 second-feet.

March 17—Hatchet Creek, Goodwater; discharge, 84 second-feet.

April 5—Choccolocco Creek, L. & N. R. R. bridge, near Jenifer; discharge, 1,170 second-feet; high water.

Oct. 16—Big Wills Creek, Wesson's Mill, 2 miles north of Attalla; discharge, 107 second-feet; low water.

6. TRIBUTARIES OF THE COOSA RIVER FROM WETUMPKA UP.

From which side.	Name of Stream.	Point on stream.	Drainage area, sq. miles.	Estimated discharge cu. ft. per sec. low water 1900-1901.	Net H.P. per ft. of fall on 80 per cent. turbine.
Left..	Sofkahatchee Creek	Mouth of Creek	40	12	1.1
Left..	Wewoka Creek	Mouth of Creek	85	28	2.5
Right	Chestnut Creek	Mouth of Creek	90	30	2.7
Left..	Hatchet Creek	Mouth of Creek	500	165	15.0
Left..	Hatchet Creek	Goodwater, Ala	105	40	3.6
Left..	Pinthlocco Creek	Mouth of Creek	60	24	2.2
Right	Weogufka Creek	Mouth of Creek	120	48	4.3
Right	Waxahatchee Creek	Mouth of Creek	196	75	6.8
Right	Yellow Leaf Creek	Mouth of Creek	192	75	6.8
Left..	Tallasseehatchee Creek	Mouth of Creek	172	70	6.3
Left..	Talladega Creek	Mouth of Creek	188	75	6.8
Left..	Talladega Creek	Nottingham, Ala	156	66	6.0
Right	Kelley's Creek	Mouth of Creek	218	88	8.0
Left..	Choccolocco Creek	Mouth of Creek	510	153	13.9
Left..	Choccolocco Creek	Jenifer, Ala	273	95	8.6
Left..	Blue Eye Creek	Mouth of Creek	26	7	0.6
Right	Broken Arrow Creek	Mouth of Creek	49	18	1.6
Right	Trout Creek	Mouth of Creek	23	10	0.9
Left..	Cane Creek	Mouth of Creek	94	35	3.2
Left..	Ohatchee Creek	Mouth of Creek	217	85	7.7
Left..	Ohatchee Creek	Above Tallasseehatchee Creek	86	35	3.2
Left..	Tallasseehatchee Creek	Mouth of Creek	125	50	4.5
Right	Shoal Creek	Mouth of Creek	31	12	1.1
Right	Beaver Creek	Mouth of Creek	33	12	1.1
Right	Big Canoe Creek	Mouth of Creek	248	90	8.2
Right	Big Canoe Creek	Above Little Canoe Creek	165	65	5.9
Right	Little Canoe Creek	Mouth of Creek	34	14	1.3
Right	Big Wills Creek	Mouth of Creek	354	160	14.4
Right	Big Wills Creek	Above Little Wills Creek	249	115	10.4
Right	Big Wills Creek	Above Wesson Mill	200	107	9.7
Left..	Black Creek	Mouth of Creek	59	25	2.3
Right	Little Wills Creek	Mouth of Creek	30	14	1.3
Left..	Ball Play Creek	Mouth of Creek	33	15	1.4
Left..	Terrapin Creek	Mouth of Creek	282	130	11.8
Right	Chattooga River	Above Little River	384	170	15.4
Right	Chattooga River	Ala.-Ga. State Line	246	121	11.0
Right	Little River	Mouth of River	280	130	11.8
Right	Coosa River	Ala.-Ga. State Line	4340	2000	181.8

NOTE—To find the net horsepower available at a shoal on one of these streams, near a point given, for low water 1900-1901, multiply the total fall of the shoal by the "net horsepower per foot fall" in this table for that point.

7. WATER POWERS ON TRIBUTARIES OF COOSA RIVER IN ALABAMA.

On the above named tributaries there are many important water powers, very few of which have been surveyed. The above list giving the drainage area, the discharge for low season, 1900-1901, and the corresponding net horse power per foot fall for each of the streams will be very useful in estimat-

ing the horse power available on any shoal, the fall of which may hereafter be surveyed, by the owners, or by parties contemplating development.

Talladega Creek, in the vicinity of Taylor's Mill, has a fall of 73 feet in one mile, where it emerges from the Crystalline rocks. Taking the flow at Nottingham, we say that during the low water of 1900 and 1901 this 73 feet of fall would have produced 438 net horse power without storage. This 73 feet is probably the most precipitous shoal on the large creek, but above it for four or five miles the creek has a number of rapids and shoals that will admit of good development.

The head waters of this stream in the neighborhood of the pyrites mines in Clay county have high falls on them.

Choccolocco Creek is a very large and constant stream, and has many rapids where good powers could be developed by dams. During a season such as low water of 1900 or 1901 a 10-foot dam near Jenifer would develop 86 net H. P. A 10-foot dam at any point near the mouth of the creek would develop 140 net H. P. during the given season.

Big Wills Creek, at the old Wesson mill, two miles north of Attalla, has a good site for a 25-foot dam. The flow at this point on October 16, 1901, was 107 second-feet, which with a fall of 25 feet, will give 242 net H. P. The fall on other tributaries named has not been ascertained.

8. COOSA RIVER SURVEY.

The Coosa River has its beginning at the junction of the Etowah and Oastanaula Rivers, at Rome, Ga., a short distance west of the Alabama line.

From Rome down to Greensport, Ala., a distance of about 180 miles by river, navigation has been carried on for many years. The total fall in this section is only about 55 feet; and is so well distributed that it has not been necessary to construct locks at any point, though improvements have been made by the U. S. Government in the way of deepening channels, blasting out reefs, and building wing dams, etc.

This part of the river will, therefore, not be considered as having any water power value.

Below Greensport, Ala., the river has a large amount of fall, and although it is proposed to make the whole distance navigable by the construction of locks, there are many fine water power propositions which can be developed in connection with

the river improvements without interfering with navigation.

A complete survey has been made of this portion of the river by the U. S. engineers, and a system of locks planned.

The profile herein presented is reproduced from that survey, and shows in addition to the river profile the location of the proposed locks, and the lift of each.

It will be seen that the total distance between Greensport and Wetumpka, Ala., is 142 miles, and the number of locks proposed, 31, varying in lift from 5.83 feet to 15.0 feet. Of these only three have been completed; Nos. 1, 2, and 3. No. 4 is in process of construction.

The following table shows the lift or fall at each lock, the discharge of river in cubic feet per second, for the minimum low stage of water in 1897 and in 1900, and the equivalent net horse power for the fall shown.

The minimum low water is based on the exceptionally low stages occurring in 1896 and 1897, which represents the lowest stage of which there is any record; while the minimum for the year 1900 represents lowest water for average years.

In estimating the amount of horse power that will be available for use, it will be necessary to deduct the amount of water which will be necessary for lockage. This will depend upon the amount of traffic on the river, but will probably in no case amount to more than ten per cent. of the river discharge.

At most of these locks, and proposed locks, reservations have been made by the original owners of the river front of the privilege of utilizing for power the water not needed for lockage. By constructing a plant at the opposite end of the Government dam from the lock, the surplus water can be used for power without interfering with navigation. Such powers will be very valuable for running cotton mills, as the cotton furrows will run up to the front door of the factory, and water transportation will take the goods from the back door. Mobile, at the mouth of the river, is only a short distance from the proposed Isthmian canal.

9. TABLE OF DISCHARGE, AND NET H. P. AT THE 31 LOCKS AND PROPOSED LOCKS ON THE COOSA RIVER AT LOWEST WATER OF 1897 AND 1900.

[80 % of Theoretical H. P.]

Miles from Wetumpka, Ala.	Lock No.	Tide Water Elevation, top of lock.	Lift or Fall in feet at lock.	Minimum Low Water, 1897.		Minimum Low Water, 1900.	
				Cubic ft. per second.	Net H. P.	Cubic ft. per second.	Net H. P.
141.5	1	521.30	5.33	1,320	640	2,700	1,308
138.5	2	515.97	5.57	1,320	668	2,700	1,367
137.0	3	510.40	12.00	1,320	1,440	2,700	2,945
116.2	4	492.30	10.00	1,350	1,227	2,760	2,510
105.8	5	482.30	12.00	1,350	1,472	2,760	3,012
92.0	6	455.32	10.00	1,440	1,310	2,940	2,673
88.3	7	445.32	10.00	1,450	1,317	2,960	2,690
81.3	8	435.32	12.00	1,490	1,625	3,040	3,317
56.2	9	420.00	8.00	1,580	1,149	3,220	2,342
53.5	10	412.00	12.00	1,585	1,728	3,230	3,523
46.7	11	399.64	10.00	1,585	1,440	3,230	2,936
44.9	12	389.64	10.00	1,600	1,454	3,260	2,964
43.0	13	379.64	12.00	1,600	1,745	3,260	3,557
41.9	14	367.64	12.00	1,600	1,745	3,260	3,557
40.2	15	355.64	10.00	1,605	1,460	3,270	2,973
37.5	16	345.64	14.00	1,605	2,044	3,270	4,162
36.1	17	331.64	15.00	1,605	2,190	3,270	4,460
34.8	18	316.64	13.00	1,610	1,903	3,280	3,877
33.8	19	303.64	12.00	1,610	1,757	3,280	3,578
31.5	20	291.64	10.00	1,610	1,464	3,280	2,982
25.5	21	281.33	10.00	1,700	1,545	3,460	3,145
21.4	22	270.80	12.00	1,700	1,854	3,460	3,774
18.5	23	258.80	14.00	1,710	2,175	3,480	4,430
16.3	24	244.80	10.00	1,710	1,554	3,480	3,164
12.9	25	234.80	10.00	1,710	1,554	3,480	3,164
11.7	26	224.80	12.00	1,720	1,877	3,500	3,818
8.8	27	212.80	14.00	1,720	2,190	3,500	4,455
7.4	28	198.80	12.00	17,20	1,877	3,500	3,818
4.6	29	186.37	8.00	1,740	1,266	3,540	2,574
2.0	30	178.37	10.00	1,740	1,582	3,540	3.218
0.0	31	168.37	14.00	1,740	2,215	3,540	4,505
Total net H. P.					49,467		100.798

Locks and proposed locks on Coosa River are located as follows:

Lock No. 1 is one mile south of Greensport, Ala., and five miles north of Singleton, which is a station on the East & West Railroad of Alabama. Lock No. 1 is three miles above lock No. 2.

Lock No. 2 is one and a half miles above lock No. 3, and is located at the head of Woods Island,, and two miles northeast of Singleton, Ala., which is a station on the East & West Railroad. This lock is situated at the head of Ten Island Shoal Canal.

Lock No. 3 is one and a half miles below lock No. 2, near the foot of Woods Island, and on Ten Island Shoal Canal. It is one mile east of Singleton, Ala., and 20.8 miles above lock No. 4.

Lock No. 4 is three and a half miles above the U. S. G. S. Hydrographic Station, Riverside, Ala., and three miles northwest of Lincoln, Ala. Lincoln and Riverside are on the Georgia Pacific division of the Southern Railway. Lock No. 4 has a lift of 12 feet, and is three-quarters of a mile below Denson's Island, and ten miles above proposed lock No. 5.

Proposed lock No. 5 is to be at the head of Ogletree Island, one mile above the mouth of Choccolocco Creek, and five miles northeast of Hamilton, on the Talladega & Coosa Valley Railroad. Has a lift of ten feet.

Proposed lock No. 6 is to be located one-fourth of a mile above the mouth of Upper Clear Creek, one and a half miles above Grissom's Ferry, and nine miles north-east of Vincent, which is a station on the Columbus & Western division of the Central of Georgia Railroad.

Proposed lock No. 7 is to be located two miles above Kelly Creek, and five and a half miles north-east of Vincent, Ala.

Proposed lock No. 8 is to be located at Myer's Ferry, at the mouth of Lower Clear Creek, six miles east of Harpersville, and three miles north-east of Creswell, which is a station on the Columbus & Western division of the Central of Georgia Railroad.

Proposed lock No. 9 is to be located at the mouth of Kelly Branch, at Fort Williams Shoals. It is to be thirteen and a half miles east of Columbiana, Ala., and eight miles east of Shelby, Ala.

Lock No. 10 is to be located a half mile above Peckerwood Creek, at the foot of Peckerwood Shoals, and is eight miles east of Shelby, Ala., and two miles west of Talladega Springs, Ala.

Lock No. 11 is to be located at the foot of Weduska Shoals, immediately above the narrows, two miles above Waxahatchee Creek, and six miles south-east of Shelby, Ala., which is a station on the Shelby Iron Works Railroad, connecting with the E. T., V. & G. R. R. at Columbiana, Ala.

Lock No. 12 is to be located 1.8 miles below lock No. 11, immediately below the mouth of Waxahatchee Creek, and eight miles south-east of Shelby, Ala.

Lock No. 13 is to be located 1.9 miles below lock No. 12, at a place known as Devil's Race, three miles above the mouth of Lower Yellow Leaf Creek, and sixteen miles north-east of Clanton, Ala., on the L. & N. R. R.

Lock No. 14 is to be located one mile below lock No. 13, two miles above Yellow Leaf Creek, and fourteen miles north-east of Clanton, Ala.

Lock No. 15 is to be located 1.7 miles below lock No. 14, three-tenths of a mile above Lower Yellow Leaf Creek, and twelve miles north-east of Clanton, Ala., on the L. & N. R. R.

Lock No. 16 is to be located 2.7 miles below lock No. 15, at Butting Ram Shoals, which is eleven miles north-east of Clanton, Ala.

Lock No. 17 is to be located 1.4 miles below lock No. 16, and is ten and a half miles north-east of Clanton, Ala.

Lock No. 18 is to be located 1.3 miles below lock No. 17, and eleven miles east of Clanton, Ala.

Lock No. 19 is to be located one mile below lock No. 18, about eleven miles east of Clanton, Ala.

Lock No. 20, 31.5 miles above Wetumpka, one-fourth mile above Zimmerman's Ferry, 1.2 miles above the mouth of Hatchet Creek.

Lock No. 21, 25.5 miles above Wetumpka, 1.6 miles below mouth of Blue Creek, 7 miles east of Cooper, Ala., on L. & N. R. R.

Lock No. 22, 21.4 miles above Wetumpka, three-fourths of a mile below the mouth of Proctors Creek, and 1.1 miles above the mouth of Pinchoulee Creek, and 7 miles east of Verbena, Ala., on the L. & N. R. R.

Lock No. 23, 18.5 miles from Wetumpka, 1.5 miles below the mouth of Pinchoulee Creek.

Lock No. 24, 16. miles above Wetumpka, 0.4 miles below the mouth of Welcree Creek, and seven and a half miles east of Mountain Creek Station, on the L. & N. R. R.

Lock No. 25, 12.9 miles above Wetumpka, 0.1 miles above the mouth of Shoal Creek, and about 8 miles east of Wadsworth, Ala., on the L. & N. R. R.

Lock No. 26, 11.7 miles above Wetumpka, at Staircase Falls, just above the mouth of Wewoka Creek.

Lock No. 27, 8.8 miles above Wetumpka, 0.6 miles above the mouth of Sofkahatchee Creek, and about nine miles east of Deatsville, Ala., on the L. & N. R. R.

Lock No. 28, 7.4 miles above Wetumpka.

Lock No. 29, 4.6 miles above Wetumpka.

Lock No. 30, 2 miles above Wetumpka.

Lock No. 31, at Wetumpka, Ala.

CHAPTER IV.

1. CAHABA RIVER AT CENTERVILLE, ALABAMA.

Centerville Station, on Cahaba River, is at the Bibb county highway bridge, one-fourth of a mile west of the court house at Centerville, Ala. The bridge is a single span iron through bridge. The length of the span is about 175 feet. The floor of the bridge is 41½ feet above low water, and the stream is 130 feet wide at low water.

The initial point of sounding is at the end of the iron bridge, left bank, down stream. The gage is a wire gage, with rod fastened to the outside of down stream guard rail, and graded to feet and tenths. The gage pulley is at Station 100. Bench mark No. 1, down stream end of top of iron crossbeam under the bridge floor at Station 100, from initial point is 42.85 above gage datum.

Bench mark No. 2, top of bottom flange of same crossbeam, directly under B. M. No. 1, is 41.40 above datum of gage.

Banks are high, but overflow at time of high water.

The section is swift, and tolerably uniform, and the bottom appears to be rock.

The river observer is Mr. S. D. Hall, a merchant, who lives about a quarter of a mile from the gage.

The following discharge measurements have been made on Cahaba River at Centerville, Ala.:

1901.

April 25—Hydrographer, J. R. Hall; gage height, 5.50; discharge, 1,925 second-feet.

Aug. 7—Hydrographer, K. T. Thomas; gage height, 1.30; discharge, 399 second feet.

1902.

Jan. 25—Hydrographer, K. T. Thomas; gage height, 5.15; discharge, 1,707 second-feet.

Daily gage height of Cahaba River at Centerville, Ala, for 1901.

Day	Aug.	Sept.	Oct.	Nov.	Dec	Day	Aug.	Sept.	Oct.	Nov.	Dec
1	......	2.20	2.10	1.20	1.4	17	7.70	2.10	1.30	1.30	12.3
2	......	2.00	2.00	1.20	1.3	18	8.10	2.60	1.30	1.30	4.4
3	......	1.90	1.80	1.20	1.6	19	9.10	3.90	1.30	1.70	3.6
4	......	1.80	1.40	1.20	1.9	20	10.60	4.10	1.30	1.60	3.1
5	......	1.60	2.30	1.20	1.8	21	14.70	2.00	1.30	1.60	2.9
6	......	1.50	4.60	1.10	1.6	22	10.30	1.90	1.30	1.50	2.6
7	1.30	1.40	3.10	1.10	1.7	23	7.90	1.80	1.30	1.60	2.5
8	1.30	1.40	2.60	1.10	1.6	24	5.60	1.60	1.20	1.60	2.6
9	1.20	1.40	2.30	1.20	1.7	25	4.80	1.50	1.20	1.50	2.7
10	1.20	1.40	1.90	1.20	2.1	26	4.10	1.40	1.20	1.50	2.7
11	1.20	1.30	1.60	1.20	2.0	27	3.90	1.40	1.20	1.50	2.7
12	1.20	1.30	1.40	1.30	1.8	28	3.40	1.40	1.20	1.40	6.0
13	1.30	1.30	1.40	1.40	1.9	29	3.00	2.60	1.30	1.40	24.0
14	1.50	2.60	1.40	1.30	2.9	30	2.80	2.20	1.30	1.40	24.0
15	2.10	2.40	1.30	1.30	19.0	31	2.50	....	1.30	....	21.0
16	7.90	2.00	1.30	1.30	15.0						

Rating table for Cahaba River at Centerville, Alabama, for year 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
1.1	326	4.9	1,694	8.7	3,062	12.5	4,430
1.2	362	5.0	1,730	8.8	3,098	12.6	4,466
1.3	398	5.1	1,766	8.9	3,134	12.7	4,502
1.4	434	5.2	1,802	9.0	3,170	12.8	4,538
1.5	470	5.3	1,838	9.1	3,206	12.9	4,574
1.6	506	5.4	1,874	9.2	3,242	13.0	4,610
1.7	542	5.5	1,910	9.3	3,278	13.1	4,646
1.8	578	5.6	1,946	9.4	3,314	13.2	4,682
1.9	614	5.7	1,982	9.5	3,350	13.3	4,718
2.0	650	5.8	2,018	9.6	3,386	13.4	4,754
2.1	686	5.9	2,054	9.7	3,422	13.5	4,790
2.2	722	6.0	2,090	9.8	3,458	13.6	4,826
2.3	758	6.1	2,126	9.9	3,494	13.7	4,862
2.4	794	6.2	2,162	10.0	3,530	13.8	4,898
2.5	830	6.3	2,198	10.1	3,566	13.9	4,934
2.6	866	6.4	2,234	10.2	3,602	14.0	4,970
2.7	902	6.5	2,270	10.3	3,638	14.1	5,006
2.8	938	6.6	2,306	10.4	3,674	14.2	5,042
2.9	974	6.7	2,342	10.5	3,710	14.3	5,078
3.0	1,010	6.8	2,378	10.6	3,746	14.4	5,114
3.1	1,046	6.9	2,414	10.7	3,782	14.5	5,150
3.2	1,082	7.0	2,450	10.8	3,818	14.6	5,186
3.3	1,118	7.1	2,486	10.9	3,856	14.7	5,222
3.4	1,154	7.2	2,522	11.0	3,890	14.8	5,258
3.5	1,190	7.3	2,558	11.1	3,926	14.9	5,294
3.6	1,226	7.4	2,594	11.2	3,962	15.0	5,336
3.7	1,262	7.5	2,630	11.3	3,998	15.1	5,366
3.8	1,298	7.6	2,666	11.4	4,034	15.2	5,402
3.9	1,334	7.7	2,702	11.5	4,070	15.3	5,438
4.0	1,370	7.8	2,738	11.6	4,106	15.4	5,474
4.1	1,406	7.9	2,774	11.7	4,142	15.5	5,510
4.2	1,442	8.0	2,810	11.8	4,178	15.6	5,546
4.3	1,478	8.1	2,846	11.9	4,214	15.7	5,582
4.4	1,514	8.2	2,882	12.0	4,250	15.8	5,618
4.5	1,550	8.3	2,918	12.1	4,286	15.9	5,654
4.6	1,586	8.4	2,954	12.2	4,322	16.0	5,690
4.7	1,622	8.5	2,996	12.3	4,358		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Minimum monthly discharge of Cahaba River at Centerville, Ala., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.

	1901.		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall	No. of days duration of minimum.
August	362	33	4
September	398	36	3
October	362	33	5
November	326	30	3
December	398	36	1

NOTE.—To find the minimum net horse power available at a shoal on this stream ,near this station, for any month, multiply the total fall of the shoal by the "net H. P. per foot of fall" in this table for that month.

2. SURVEY OF CAHABA RIVER, ALABAMA.

The Cahaba River rises near Birmingham, Alabama, and flowing in a southerly direction, enters the Alabama River at a point just below Selma, Alabama.

From the published notes of a survey made by the Corps of Engineers, U. S. A., a profile has been made beginning at the southwestern boundary of Shelby county, and running down the river a distance of 110 miles to its mouth, in which distance there is a fall of 227 feet.

A United States Geological Survey hydrographic station has been established at Centerville, Ala,. and measurements of discharge have also been made at Sydenton, near Birmingham, but the measurements and observations have not extended over a sufficient length of time to give accurate estimates of discharge at all seasons. The best that can be done at present is to form an estimate of the river discharge for ordinary low stage of water at Centerville, which is 344 second-feet, and add to or subtract from this amount for other points on the river. From measurements made on the same day at Centerville and at Harrell, near the mouth of the river, we estimate that the flow at Centerville is about one-third of that at the mouth of the river.

On the accompanying profile the stations are one mile apart, and are numbered from zero at the mouth of the river, up to 110 at the Shelby county line. In the following description of powers that can be developed these mile stations will be referred to as stations:

Power No. 1.—From the head of "Half Mile Rapids" at Station 108 there is a succession of shoals known as Half Mile, Long Island, Fish Trap, Ford, Reach, and Dry Creek Shoals, in which the aggregate fall is 30 feet in 2¼ miles. There is also a fall of about 4 feet from the Shelby County line down to the head of Half Mile Shoal, making a total fall of 34 feet in four miles. This can be developed either by building a dam 34 feet high at the mouth of Dry Creek and backing the water to the Shelby County line, or by building a low dam near the head of the shoals, and a canal from it to a point opposite the mouth of Dry Creek. Such a development will give about 500 net horse-power, with an 80% turbine at ordinary low season. This power would be near Blocton, Ala.

Power No. 2.—By building a 15-foot dam at the head of "Baily Reach Rapids," near Station 101, and near the mouth of Big Ugly Creek, to back the water to the mouth of Persimmon branch near Station 104, and constructing from this point a canal along the river bank about four miles long, to a point opposite Station 97, at the mouth of Little Cahaba River, a practical head of 54 feet can be developed. This allows 8 feet for storage and grade, as the total fall is 62 feet. A 54-foot fall would produce about 800 net H. P.

The same power can be developed by building a high dam, lower down the river, and having the canal shorter. Or, the power can be divided into two separate powers. This power site is between River Bend and Cadle, in Bibb County.

Power No. 3.—From the mouth of Little Cahaba down to Station 88½ at the top of Centerville Shoals, there is a fall of ten feet in 8½ miles, and from the top of Centerville Shoals down to the foot of Centerville Shoals at Centerville, there is a fall of 13.6 feet in about 1¾ miles. This power can be developed by a ten-foot dam at top of Centerville Shoals, and a canal from there to Centerville 1½ miles long. Allowing 2.6 feet for storage and canal grade, a head of 21 feet can be obtained which will give 650 net H. P.

It is probable that a much better method of development will be to erect a dam at Centerville 23.6 feet high to back the

water to the mouth of Little Cahaba. This will produce 732 net H. P., with storage. The incidental storage of such a dam would add largely to the amount and efficiency of the power. A plant running only 12 hours per day, and storing the water at night, could utilize 1,440 net H. P.

This power site is at Centerville, Alabama, on the M. & O. Railroad.

Power No. 4.—A 16-foot dam can be built at Shoal No. 9, Station 69½, in Perry County, just below the Bibb County line. This dam would back the water for 12 miles to Shoal No. 2, 4½ miles below Centerville. A 16-foot head will produce 670 H. P. without storage, or 1,340 H. P. by storing the water at night, and running only twelve hours per day. This dam site is about 17 miles below Centerville by river.

Power No. 5.—A 15-foot dam at "Blocks Cut-off," near Station 55, will back the water ten miles to the mouth of Taylor's Creek, and will produce 750 continuous, or 1,500 twelve-hour horse power.

Power No. 6.—At Shoal No. 24, Station 50, there is a fall of 9 feet in less than half a mile. A 14-foot dam at foot of this shoal, or a 5-foot dam at its head, and a short canal will develop a head— of 14 feet and realize 720 continuous, or 1,400 twelve-hour H. P.

This site is just above Burras Island, 8 or 10 miles northeast of Marion, Ala.

Power No. 7.—From Burras Island to Fikes Ferry there is a fall of 22 feet in a distance of 7 miles, 20 feet of which could probably be utilized by a dam at Fikes Ferry, producing 1,100 continuous, or 2,200 twelve-hour H. P. Fikes Ferry is near Marion, Ala.

In making the above statement of powers that can be developed, it has been assumed that there are suitable banks for dam sites. The system proposed, or some other system approximating to it, would not interfere with navigation improvements, as locks could be constructed at the dams.

CHAPTER V.

BLACK WARRIOR RIVER AND TRIBUTARIES

1. TUSCALOOSA STATION ON BLACK WARRIOR RIVER.

This gage was placed in position by the United States Corps of Engineers in 1888. It is about three-fourths of a mile from the business center of Tuscaloosa, Alabama, and is reached by passing down Bridge street to the river, thence down the east bank 1,800 feet to the gage. It consists of an inclined timber, 2x6 inches, supported on posts and graduated by means of notches placed 1 foot vertically apart. The observer is W. S. Wyman, Jr., Tuscaloosa, Alabama. Mr. Wyman is observer for the Corps of Engineers, and has been kind enough to send weekly reports to this office. Observations are taken daily at 7 A. M. The area draining past this point is 4,900 square miles.

The bench marks are fixed, one on a willow 10 feet west of gage, 97.84 feet above Mobile datum, the other on a small hackberry 30 feet south of the upper end of the gage and 139.36 feet above Mobile datum. The current here is rather sluggish, being almost imperceptible at low stages. Both banks are of earth, and subject to overflow. Observations of gage heights have been obtained through the courtesy of Mr. R. C. McCalla, Jr., of the United States Engineers in charge of the Black Warrior River, from the time the gage was established until December 31, 1896. A measurement made by Mr. McCalla September 14, 1896, showed a gage height of —0.60 foot area, 1,022 square feet, mean velocity 0.16, discharge 164 second-feet.

The following list of measurements at the same place has been furnished by Mr. Horace Harding, C. E., United States assistant enginee, 2016 Quinlan avenue, Birmingham, Alabama. Velocities were obtained by means of rod floats reaching from the water surface to near the bottom. The highest flood occurred on April 8, 1892. The gage height was 62.5, the sectional area 33,600 square feet, and the estimated mean velocity 4.5 feet per second. This gave a discharge of 151,200 cubic feet per second. From this estimate and the following list of measurements a curve has been plotted and a rating table constructed, and this rating table applied to all gage heights observed. The estimates of discharge thus obtained are shown in diagrammatic form in Plate V. The highest discharges are merely approximations, but the discharges shown by the diagrams serve as a basis for comparison of the state of the river during the various years.

List of Discharge Measurements made on Black Warrior River at Tuscaloosa, Alabama.

No.	Date.	Gage height.	Discharge.	Remarks.
	1895.	*Feet.*	*Second-feet.*	
1	Dec. 17	1.10	617	Stationary.
2	Dec. 21	2.61	1,344	Do.
3	Dec. 24	3.60	1,733	Rising slowly.
	1896.			
4	Jan. 30	9.99	5,073	Falling 0.05 per hour.
5	Jan. 31	8.65	4,363	Do.
6	Feb. 26	8.25	4,360	Falling 0.01 per hour.
7	Feb. 28	7.27	3,657	Falling 0.02 per hour.
8	Feb. 29	6.92	3,522	Stationary.
9	Mar. 2	7.67	4,211	Do.
10	Mar. 3	7.28	3,632	Falling 0.03 per hour.
11	Mar. 6	6.94	4,558	Rising 0.15 per hour.
12	Mar. 24	24.85	13,550	Falling 0.12 per hour.
13	Apr. 10	9.71	5,331	Falling.
14	Apr. 11	8.89	4,755	Do.
15	Apr. 14	8.25	4,675	Rising.
16	Apr. 20	7.55	3,862	Falling.
17	Apr. 21	6.65	3,388	Do.
18	Apr. 22	5.96	2,940	Do.
19	Apr. 23	5.46	2,704	Do.
20	Apr. 24	5.88	3,158	Rising.
21	Apr. 27	5.68	3,049	Do.

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1889.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	15.00	23.50	18.80	8.50	8.80	2.30	2.40	3.70	0.75	2.40	0.90	6.00
2..........	19.50	20.50	16.50	9.80	14.50	2.90	3.10	3.60	7.30	1.95	1.05	5.65
3..........	18.00	17.50	25.00	10.30	13.20	2.75	4.40	3.00	6.40	1.55	1.85	5.30
4..........	16.00	14.80	31.50	11.60	11.00	2.50	5.10	2.95	5.30	1.30	1.90	4.80
5..........	25.00	13.00	29.40	10.50	8.50	2.30	6.25	2.90	6.20	1.15	3.85	4.50
6..........	33.00	11.50	26.50	9.50	7.00	2.10	6.85	3.70	9.80	1.05	3.65	4.20
7..........	33.50	10.40	23.00	8.40	5.80	1.90	6.45	3.45	14.90	.90	3.30	4.00
8..........	29.50	9.30	20.10	7.30	4.60	1.70	5.70	2.95	19.00	.70	3.00	3.80
9..........	26.80	8.30	17.50	6.80	4.30	2.00	4.75	2.60	14.00	.50	2.75	3.60
10..........	28.40	8.00	15.00	6.40	4.00	2.60	3.85	2.00	9.90	.40	2.55	3.40
11..........	29.00	7.80	12.80	6.30	3.80	2.85	3.05	1.75	5.50	.30	3.65	3.20
12..........	25.50	7.60	11.00	6.00	3.20	4.20	2.85	1.55	5.25	.30	4.30	2.95
13..........	22.50	7.30	10.00	5.60	3.00	3.40	2.45	3.85	4.15	.20	4.15	2.75
14..........	19.00	7.00	9.20	5.50	3.10	4.00	2.15	3.60	3.30	.15	3.75	2.70
15..........	16.00	7.30	8.80	8.00	3.20	3.45	1.95	3.35	2.70	.15	3.50	2.65
16..........	13.60	27.50	8.10	16.80	3.00	3.25	4.20	3.15	2.25	.15	4.20	2.50
17..........	29.00	49.00	7.20	16.70	2.80	3.05	7.35	3.80	2.00	.10	5.20	2.30
18..........	40.50	56.40	7.10	14.00	2.50	2.85	11.35	3.50	1.55	.10	12.45	2.20
19..........	38.50	56.60	11.00	12.00	2.35	2.65	11.50	3.20	1.40	.05	18.90	2.10
20..........	34.00	53.00	12.50	10.00	2.25	2.45	8.40	2.90	1.30	.05	16.90	2.05
21..........	30.30	47.00	12.30	8.90	2.05	2.25	4.60	2.40	1.20	.05	14.10	2.00
22..........	28.10	41.50	11.80	8.00	1.85	3.25	4.55	1.90	1.10	.05	11.70	2.00
23..........	26.00	36.50	10.80	7.00	1.65	3.45	4.50	1.50	1.00	— .10	9.70	2.00
24..........	23.10	32.50	10.00	6.40	1.50	3.20	3.70	1.20	1.00	— .30	7.90	2.00
25..........	21.00	28.50	9.80	6.30	1.30	3.00	3.15	.90	.95	— .15	6.60	1.95
26..........	20.40	26.50	11.20	6.80	1.25	2.40	3.10	.75	2.25	+ .10	6.30	1.95
27..........	25.00	23.50	11.80	6.50	1.15	1.95	4.55	1.00	3.70	.35	6.10	1.95
28..........	33.50	21.40	12.30	6.20	1.05	1.55	4.05	.95	3.50	.35	5.90	1.90
29..........	33.80	......	11.00	5.80	.95	1.25	4.00	.90	3.25	.40	5.80	1.90
30..........	30.00	......	10.50	5.50	1.15	1.10	4.00	1.10	2.60	.90	6.30	3.00
31..........	27.00	......	9.80	......	1.10	....	3.80	1.05	......	1.00	......	4.85

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1890.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	7.70	30.20	58.90	24.50	16.70	7.75	1.80	5.00	8.00	9.30	3.75	1.00
2..........	7.20	26.20	57.40	34.50	13.70	6.50	1.65	4.05	5.80	7.40	3.35	1.00
3..........	6.20	22.50	52.40	34.10	11.95	5.65	1.45	3.25	4.35	6.10	3.10	1.00
4..........	5.20	19.05	45.80	43.60	12.75	5.00	1.25	2.85	3.40	5.10	2.85	1.00
5..........	5.20	16.40	40.85	45.90	14.65	4.40	1.10	3.15	3.10	4.40	2.55	1.00
6..........	4.80	13.90	37.15	44.50	16.50	4.00	.80	3.35	3.85	3.80	2.40	1.00
7..........	4.50	12.10	35.40	38.70	15.00	5.20	.60	3.75	4.35	3.50	2.25	1.20
8..........	4.55	44.30	32.60	34.00	13.50	5.60	.50	4.55	4.80	3.45	2.15	10.05
9..........	5.10	53.95	30.50	29.95	11.95	5.40	.45	4.30	2.85	4.50	2.05	10.10
10..........	5.30	52.90	27.50	26.70	10.10	5.25	.30	4.30	3.20	4.45	2.00	8.95
11..........	5.60	47.50	25.00	23.45	9.30	5.00	.20	6.10	2.90	4.10	1.95	7.10
12..........	5.45	42.20	23.00	20.45	8.35	6.00	.15	6.40	3.45	3.80	1.75	5.80
13..........	5.30	37.20	20.75	17.45	8.35	6.20	.05	5.30	3.95	3.50	1.65	4.60
14..........	5.20	32.65	22.50	14.50	9.00	6.20	1.05	4.50	5.80	3.20	1.60	3.70
15..........	5.60	29.45	38.20	12.15	8.75	5.60	2.55	3.20	5.55	2.80	1.60	3.30
16..........	11.20	26.95	38.00	10.65	8.65	5.05	3.10	2.80	4.50	2.70	1.55	2.95
17..........	19.30	23.95	35.80	10.35	9.50	4.35	3.55	2.50	3.55	2.60	1.65	2.80
18..........	21.00	21.45	32.30	12.95	8.90	4.30	3.65	2.70	2.90	2.40	1.60	2.75
19..........	18.40	18.45	29.00	13.20	8.15	4.20	4.15	2.55	2.45	2.30	1.55	2.20
20..........	15.40	15.65	27.20	13.95	7.95	3.70	4.75	2.40	2.10	2.10	1.50	2.00
21..........	13.30	13.45	32.40	12.15	7.95	3.20	4.20	2.20	1.75	2.00	1.50	2.00
22..........	11.60	12.00	34.45	10.45	9.00	2.80	3.00	1.80	1.70	2.45	1.45	1.90
23..........	10.10	10.40	41.25	9.30	8.40	2.50	2.10	1.40	3.05	4.90	1.35	1.90
24..........	10.70	9.40	40.25	10.65	7.65	2.25	1.75	1.10	3.10	8.45	1.30	1.80
25..........	12.50	9.50	36.75	15.45	6.95	2.25	2.75	1.00	13.05	10.55	1.25	1.80
26..........	13.50	13.50	33.35	26.50	6.85	2.15	12.65	.95	23.90	9.60	1.20	2.30
27..........	12.80	35.20	29.70	28.45	9.60	2.55	13.40	.95	22.65	8.05	1.15	6.80
28..........	11.80	53.10	27.45	26.20	13.20	2.25	10.50	5.10	18.00	6.45	1.10	9.70
29..........	10.60	......	24.55	23.35	13.55	2.05	9.50	9.55	14.70	5.30	1.05	10.20
30..........	17.60	......	21.95	19.80	11.95	1.90	7.45	9.15	11.90	4.90	1.00	9.10
31..........	31.70	......	18.80	......	9.25	....	6.50	10.45	......	4.15	......	7.30

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1891.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	6.10	33.20	24.00	34.00	5.70	1.80	2.10	6.50	1.00	—0.40	—0.80	3.40
2..........	8.60	39.60	23.50	39.40	5.50	1.90	2.00	13.00	1.00	— .30	— .80	3.00
3..........	14.30	40.90	20.50	36.80	5.30	1.80	1.90	14.80	1.00	— .20	— .80	2.40
4..........	17.90	40.20	19.60	32.50	4.90	1.70	1.80	16.00	.80	— .20	— .80	6.20
5..........	15.20	39.30	17.20	28.50	4.50	1.50	1.50	13.00	.70	— .20	— .80	6.80
6..........	13.10	36.30	29.00	25.00	4.50	1.40	1.30	9.50	.60	& .20	— .80	21.50
7..........	11.10	37.00	53.00	22.20	4.20	1.40	1.40	7.40	.60	— .40	— .80	19.50
8..........	10.00	51.50	58.00	19.00	4.00	1.50	2.10	5.80	.60	— .50	— .80	20.00
9..........	9.50	51.50	60.40	16.00	3.90	2.10	7.00	5.40	.60	— .60	— .80	20.50
10..........	17.50	52.20	58.00	14.20	3.50	2.80	10.40	3.70	.60	— .70	+ .70	17.00
11..........	20.90	53.50	54.00	17.20	3.20	3.50	8.20	3.10	.70	— .80	2.10	14.00
12..........	26.30	50.50	48.00	27.00	3.20	10.20	6.00	2.70	1.00	— .80	2.80	11.50
13..........	30.10	47.60	43.00	26.00	3.10	10.50	4.30	2.50	1.20	— .80	4.40	9.00
14..........	25.50	51.40	40.00	22.50	3.00	9.80	3.20	3.00	1.20	— .80	3.80	6.20
15..........	21.00	49.50	36.50	19.50	2.80	8.00	2.30	3.40	1.00	— .60	2.50	7.00
16..........	18.50	46.50	33.20	17.20	2.60	6.50	2.60	4.00	1.00	— .70	2.00	9.00
17..........	17.10	44.30	3[illegible].00	15.60	2.50	5.60	2.60	3.00	.60	— .70	1.80	11.00
18..........	17.70	41.00	28.00	16.40	2.50	6.30	2.90	2.60	.20	— .70	1.80	11.20
19..........	17.10	37.50	26.40	14.50	2.50	7.20	2.50	2.20	.10	— .60	1.50	10.00
20..........	15.60	35.00	24.00	13.40	2.50	7.00	2.20	2.00	.10	— .70	1.30	8.50
21..........	12.60	33.50	21.00	12.00	2.50	6.00	1.80	1.50	.10	— .70	1.40	7.00
22..........	20.20	39.50	19.90	11.00	2.70	5.50	1.60	1.60	.10	— .60	3.00	6.00
23..........	31.60	41.00	17.50	10.00	3.00	5.20	1.40	1.40	.10	— .60	8.00	6.00
24..........	31.80	39.00	15.00	9.00	3.00	4.80	1.30	1.30	.10	— .50	12.30	6.20
25..........	30.10	36.50	12.50	8.20	2.80	4.50	1.40	1.20	.00	— .50	13.30	7.50
26..........	30.70	33.00	12.10	7.60	2.60	4.20	2.60	1.10	.00	— .50	10.80	13.20
27..........	29.00	29.00	15.00	8.40	2.50	4.10	2.00	1.10	— .20	— .70	7.20	31.00
28..........	26.80	26.50	18.20	8.00	2.40	3.70	2.20	1.00	— .20	— .80	5.80	38.90
29..........	23.70	......	19.40	7.30	2.30	2.90	2.00	1.00	— .40	— .80	4.20	31.20
30..........	32.70	......	18.00	6.50	2.10	2.50	2.10	1.10	— .50	— .80	3.80	27.00
31..........	33.00	......	17.00	......	2.00	......	2.40	1.00	......	— .80	......	22.10

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1892.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	17.90	21.20	10.70	21.80	12.00	3.40	4.60	4.80	9.30	3.90	0.40	5.90
2..........	15.90	10.50	10.30	18.30	11.20	3.20	3.90	3.20	7.60	3.50	.40	5.60
3..........	18.50	9.40	9.70	15.50	9.90	3.50	3.40	7.00	6.50	3.30	1.20	5.30
4..........	18.70	8.50	8.80	15.20	8.80	3.70	3.00	7.40	5.60	3.10	1.60	4.90
5..........	16.40	7.80	8.00	12.00	7.20	3.50	2.90	6.60	4.90	2.80	1.60	6.30
6..........	14.60	7.40	7.80	11.60	6.50	4.70	3.50	5.40	4.90	2.50	1.60	7.50
7..........	13.00	7.80	8.00	56.30	5.90	5.00	5.20	4.80	4.80	2.40	2.00	7.50
8..........	11.60	7.50	16.50	63.20	5.30	4.90	11.00	3.90	6.40	2.20	3.90	12.20
9..........	10.80	9.00	26.80	62.20	5.20	4.10	26.70	3.60	6.20	2.10	4.60	15.00
10..........	10.50	16.00	28.50	58.00	4.90	4.00	43.50	3.50	5.40	2.00	8.90	13.20
11..........	25.70	13.00	26.70	52.30	4.90	3.80	46.20	3.00	5.10	2.00	10.90	11.00
12..........	34.80	11.30	22.00	45.40	4.80	3.50	41.40	3.00	3.90	2.00	8.30	9.40
13..........	53.00	10.80	18.00	40.70	4.70	3.30	38.30	3.30	3.40	2.00	7.60	8.00
14..........	57.40	9.50	15.80	36.50	4.60	2.80	37.50	3.10	3.30	1.90	5.80	7.40
15..........	55.90	9.00	13.80	32.80	4.50	2.50	34.80	3.90	4.00	1.90	5.00	8.60
16..........	51.70	10.00	13.30	29.50	4.00	2.40	32.80	3.50	5.10	1.90	4.50	10.30
17..........	45.00	11.80	11.20	27.00	3.70	2.00	41.40	3.50	4.90	1.80	4.00	13.10
18..........	40.10	11.00	12.90	24.50	3.60	1.80	38.00	6.00	4.30	1.70	4.20	26.70
19..........	36.60	9.90	24.00	22.40	4.30	2.10	33.00	9.50	6.00	1.00	4.40	28.40
20..........	41.50	10.50	25.50	20.20	4.60	3.90	29.00	11.50	18.30	1.00	4.70	28.40
21..........	41.00	13.50	22.90	18.10	6.50	7.40	28.30	9.50	23.90	.90	5.00	36.50
22..........	36.80	18.00	20.00	15.90	6.30	10.80	29.30	7.40	20.90	.90	4.80	35.80
23..........	34.40	23.90	18.30	13.80	6.00	10.70	25.10	10.20	17.00	.90	4.50	31.50
24..........	31.00	21.20	22.00	12.30	6.00	8.40	21.50	12.30	13.30	1.00	4.20	27.00
25..........	28.50	18.50	29.00	11.30	4.80	7.80	18.80	14.00	10.50	1.00	3.80	23.00
26..........	26.00	16.00	32.00	10.50	3.50	7.90	15.80	14.20	8.00	.90	3.50	19.50
27..........	23.80	14.00	35.80	8.80	4.70	7.20	13.00	13.20	6.10	.80	3.30	16.00
28..........	21.50	12.50	34.00	7.90	4.00	6.10	10.50	11.50	5.00	.70	3.20	13.60
29..........	19.00	11.50	30.50	7.70	3.80	5.20	7.80	12.00	4.90	.70	3.90	11.40
30..........	16.80	......	26.80	10.50	3.50	5.40	6.20	11.50	4.30	.50	5.90	9.80
31..........	14.00	......	23.90	......	3.50	.....	5.50	10.50	......	.50	......	8.50

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1893.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	8.20	18.10	23.00	9.40	24.50	12.50	2.50	0.60	0.30	1.10	0.40	1.50
2..........	8.60	15.90	21.70	9.30	21.20	33.50	2.50	.70	.20	1.00	.40	1.50
3..........	9.80	14.00	19.70	9.00	30.00	49.60	2.80	1.00	.10	1.20	.40	1.80
4..........	10.70	12.80	20.50	8.70	51.20	46.00	3.60	1.20	.00	1.40	.40	2.80
5..........	10.10	12.50	23.00	8.00	52.20	39.00	3.60	1.30	— .10	1.30	.40	3.50
6..........	9.00	11.80	24.00	8.70	48.00	37.70	3.20	1.20	— .10	1.20	.40	4.20
7..........	8.40	11.20	22.60	9.30	42.90	39.90	2.70	1.30	.00	1.20	.40	4.10
8..........	7.90	10.80	20.10	9.00	40.40	39.30	2.40	1.20	+ .20	1.20	.40	3.50
9..........	7.00	10.60	20.00	8.30	37.40	34.00	2.10	1.00	1.40	1.00	.40	3.00
10..........	6.70	10.20	22.00	7.60	34.30	29.20	1.80	.90	2.00	.90	.60	2.80
11..........	6.20	12.00	21.80	7.00	30.80	25.10	1.60	.90	2.10	.80	.60	2.30
12..........	6.50	23.90	20.50	6.40	27.50	21.20	1.60	.80	2.20	.80	.50	1.90
13..........	7.80	28.30	19.30	6.10	24.40	17.40	2.20	.90	3.20	.80	.50	1.70
14..........	9.00	27.00	18.10	5.80	21.90	14.70	2.60	3.60	4.30	.70	.60	1.60
15..........	9.60	25.90	16.30	23.00	19.10	11.60	2.40	4.90	4.30	.70	.60	1.50
16..........	11.40	52.20	14.70	27.10	16.20	9.60	2.00	5.10	3.90	.60	.60	1.70
17..........	12.20	55.60	13.20	24.00	14.00	7.60	1.70	4.70	3.30	.50	.60	2.30
18..........	11.80	54.70	12.20	20.00	11.90	6.70	1.40	3.70	2.50	.50	.60	2.40
19..........	12.00	51.40	11.30	16.40	11.00	6.50	1.30	2.80	2.10	.50	.60	2.30
20..........	12.40	46.50	10.70	13.90	8.40	6.90	1.20	2.20	1.80	.50	.60	2.10
21..........	11.80	41.80	9.90	12.00	6.90	6.90	1.20	1.70	1.40	.50	.70	2.50
22..........	10.90	37.90	9.30	11.20	6.20	6.60	1.30	1.50	1.30	.50	1.00	2.40
23..........	11.20	34.50	8.80	10.70	5.60	6.40	1.00	1.30	1.20	.40	1.00	2.30
24..........	12.90	31.30	12.30	9.90	5.10	5.70	1.70	1.10	1.00	.40	1.10	2.10
25..........	15.90	28.40	22.20	8.90	4.80	4.90	1.50	1.00	1.30	.40	1.00	1.90
26..........	19.20	25.90	22.50	7.00	4.50	4.40	1.30	.90	1.20	.40	.90	1.70
27..........	22.00	23.80	20.00	10.50	4.30	4.00	1.20	.80	1.20	.40	1.00	1.60
28..........	23.30	23.00	17.00	32.50	5.10	3.50	.90	.80	1.10	.40	1.70	1.50
29..........	23.10	......	14.40	33.90	6.10	3.10	.90	.60	1.10	.40	1.70	1.40
30..........	22.10	......	12.40	29.00	12.90	2.80	.80	.50	1.10	.40	1.50	3.70
31..........	20.40	......	10.90	......	14.10	.....	.80	.20	......	.40	......	7.60

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1894.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	10.30	8.50	27.00	11.40	6.50	1.70	2.50	1.20	5.80	0.55	—0.05	—.05
2..........	9.60	7.80	25.60	14.10	5.90	1.60	1.80	1.30	4.60	.45	— .10	—.05
3..........	7.90	7.30	23.60	23.50	5.90	1.50	1.35	1.40	3.60	.40	— .20	.00
4..........	6.20	7.90	21.00	24.00	5.80	1.35	1.10	1.95	2.95	.32	— .25	.00
5..........	5.40	16.90	18.20	22.20	5.50	1.33	.80	2.30	2.45	.25	— .30	.00
6..........	6.40	22.60	15.90	20.60	5.20	1.20	.60	2.40	2.05	.20	— .30	.00
7..........	16.80	20.40	14.80	18.90	5.10	1.20	1.00	2.00	1.85	.15	— .30	.00
8..........	22.60	17.80	14.40	16.30	4.90	1.10	1.80	1.60	1.75	.00	— .30	+.05
9..........	19.70	17.30	13.80	14.70	4.50	.95	.70	1.30	1.65	— .10	— .30	.05
10..........	26.90	26.00	12.60	15.70	4.10	.90	.70	1.10	1.60	— .20	— .30	.50
11..........	34.50	27.80	11.60	25.00	3.70	.80	.60	.80	1.85	— .25	— .30	2.10
12..........	35.80	25.40	11.50	25.10	3.90	.80	.60	.70	3.40	— .30	— .30	5.70
13..........	30.90	29.90	16.50	22.70	4.30	.70	.50	.60	5.60	— .30	— .30	10.40
14..........	25.80	32.10	17.30	19.50	7.00	.60	.50	.50	7.50	— .30	— .10	11.20
15..........	22.20	29.70	15.80	16.30	6.20	.60	.60	.35	5.70	— .30	.00	8.90
16..........	23.60	26.00	15.50	15.50	5.70	.60	.70	.60	4.20	— .30	+ .05	6.40
17..........	24.80	22.30	33.10	16.00	5.10	.55	.75	.55	3.25	— .30	.05	4.90
18..........	22.40	19.10	36.70	17.00	5.00	.50	.70	.45	3.50	— .30	.05	3.90
19..........	19.30	16.80	33.70	25.30	4.70	.60	.70	.40	3.25	— .30	.00	3.20
20..........	15.90	16.00	29.50	24.80	4.20	.70	.60	.55	3.25	— .30	— .10	2.90
21..........	14.10	16.90	27.80	24.00	3.60	.85	.50	1.00	4.10	— .30	— .10	2.60
22..........	18.60	17.90	29.30	20.40	3.10	.80	.90	1.35	3.60	— .30	— .10	2.20
23..........	21.30	17.00	29.60	17.30	2.80	.95	1.30	3.80	2.90	— .30	— .10	2.00
24..........	19.90	16.10	28.00	14.20	2.60	1.10	1.35	5.30	2.20	— .35	.00	1.80
25..........	17.60	17.30	27.80	12.20	2.40	1.00	1.60	9.20	1.75	— .40	.00	1.70
26..........	15.50	29.30	25.30	10.50	2.30	1.05	1.50	16.00	1.45	— .40	.00	2.00
27..........	14.00	31.00	22.10	9.80	2.10	1.40	1.40	20.40	1.20	— .45	— .05	7.70
28..........	12.40	28.80	19.00	8.70	2.10	1.70	1.30	16.00	1.05	— .45	— .05	9.70
29..........	11.10	......	16.10	7.90	2.00	2.35	.20	11.80	.90	— .45	— .05	8.40
30..........	10.00	......	14.30	7.00	1.90	2.60	1.10	8.30	.70	— .20	— .05	7.20
31..........	9.10	......	12.70	......	1.90	....	1.20	6.80	......	— .05	— .05	6.50

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1895.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	6.10	24.10	8.60	16.20	15.20	7.00	4.80	1.80	1.90	0.10	—0.04	0.75
2..........	5.40	21.50	13.20	14.50	13.00	5.90	4.50	1.50	1.80	.00	+ .07	.95
3..........	6.80	21.40	35.30	12.60	11.00	5.10	5.40	1.30	1.80	— .07	.12	1.05
4..........	9.00	21.40	36.70	11.00	9.40	4.60	7.60	1.20	1.70	— .10	.09	1.00
5..........	8.80	19.90	32.40	10.20	8.30	4.20	17.40	1.20	1.90	— .10	.11	.90
6..........	8.00	17.90	27.80	8.40	7.40	6.70	17.70	1.20	2.60	— .10	.25	1.30
7..........	7.40	16.50	23.80	7.90	7.00	5.70	18.40	1.10	3.05	— .10	.31	1.50
8..........	35.00	16.80	20.60	20.50	8.20	5.10	15.70	1.00	3.70	.00	.30	1.45
9..........	50.60	16.90	20.10	24.00	13.50	4.30	13.10	.90	3.40	— .03	.28	1.90
10..........	49.30	15.80	19.30	21.20	19.70	3.80	11.10	.97	2.90	— .07	.70	1.80
11..........	45.10	14.60	17.50	18.00	23.30	3.10	9.80	1.40	2.40	— .10	1.20	1.45
12..........	40.10	14.10	17.20	15.10	22.00	2.70	7.90	1.50	2.20	— .14	1.10	1.40
13..........	35.00	13.90	18.40	12.60	18.50	2.40	6.50	1.40	2.10	— .14	1.18	1.40
14..........	29.80	12.80	24.90	11.00	15.20	2.20	5.30	1.30	2.00	+ .06	1.35	1.37
15..........	25.70	11.60	37.50	9.50	12.20	2.00	5.40	1.10	1.80	.04	1.35	1.33
16..........	23.40	10.50	47.40	8.60	9.70	2.00	5.60	1.30	1.60	— .08	1.28	1.23
17..........	31.20	9.40	52.00	10.00	8.00	2.70	5.90	1.40	1.40	— .18	1.20	1.12
18..........	32.90	9.00	47.30	15.90	6.90	3.30	5.80	2.00	1.40	— .27	1.05	1.05
19..........	29.20	9.00	42.10	15.80	6.30	4.20	5.10	4.00	1.30	— .31	.88	1.02
20..........	25.80	9.50	38.80	14.00	5.90	4.90	4.60	4.30	1.00	— .37	.82	1.57
21..........	23.10	10.20	48.70	12.00	5.30	4.70	4.00	3.60	1.20	— .42	.70	2.55
22..........	21.60	10.90	51.30	10.40	4.80	4.30	3.60	2.80	1.50	— .45	.60	2.60
23..........	21.60	11.40	47.60	8.90	4.30	4.10	3.40	2.40	1.30	— .50	.50	3.03
24..........	19.80	11.30	42.10	8.00	4.10	3.70	3.30	4.30	1.10	— .35	.75	3.65
25..........	17.40	10.90	37.30	7.20	4.00	3.40	3.60	4.90	.80	— .33	.60	3.31
26..........	16.70	10.30	32.80	7.00	4.30	3.00	3.70	4.00	.60	— .53	.38	4.50
27..........	20.00	9.70	29.10	7.10	5.60	4.40	3.30	3.20	.35	— .70	.64	10.40
28..........	21.20	9.00	26.10	12.50	11.00	5.40	2.90	2.40	.10	— .68	.65	21.02
29..........	22.00	......	23.60	15.00	13.30	6.00	2.40	2.30	.50	— .67	.65	16.88
30..........	27.40	......	21.10	16.40	11.20	5.40	2.00	2.10	.30	— .50	.60	13.10
31..........	27.10	......	18.60	......	8.90	....	2.10	2.00	......	— .32	......	11.67

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1896.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	11.41	7.92	6.91	10.61	18.24	4.92	1.94	.53	.38	— .52	— .78	7.70
2..........	10.26	8.51	7.66	14.78	33.30	4.28	1.71	.80	.25	— .62	— .77	6.32
3..........	8.90	21.98	7.41	23.00	37.18	3.50	1.44	1.34	.15	— .66	— .42	4.63
4..........	7.60	33.12	6.74	23.50	30.88	5.44	1.48	.89	.05	— .20	— .39	3.40
5..........	6.55	30.02	6.14	19.85	26.40	5.24	1.80	.54	— .06	+ .78	— .33	2.60
6..........	5.74	30.75	6.64	16.70	21.93	4.30	1.15	.42	— .15	.74	— .19	2.05
7..........	5.09	35.92	10.18	14.26	17.88	3.62	1.32	.50	— .23	.68	— .19	1.70
8..........	5.24	35.08	12.04	12.55	13.95	3.27	2.20	.60	— .30	.40	— .17	1.47
9..........	5.76	36.21	14.89	11.20	10.80	6.60	8.40	.68	— .37	.09	— .18	1.21
10..........	6.46	36.52	13.69	10.02	8.60	8.18	6.98	.64	— .44	— .15	— .21	1.10
11..........	6.58	33.65	12.45	9.04	7.11	18.39	5.37	.55	— .44	— .28	— .30	.89
12..........	6.25	29.45	13.97	8.33	6.09	15.13	3.95	.45	— .46	— .28	— .20	.84
13..........	5.79	25.97	16.15	7.62	5.34	10.77	2.99	.38	— .50	— .48	— .22	.80
14..........	5.26	27.41	15.35	7.86	4.77	7.66	2.45	.35	— .60	— .49	— .11	.75
15..........	4.82	33.25	13.56	11.65	6.13	5.60	2.16	.31	— .59	— .46	— .10	1.20
16..........	4.87	31.02	13.86	13.90	5.45	4.33	2.13	.26	— .59	— .43	— .01	1.25
17..........	6.03	27.30	22.30	12.36	4.65	4.74	2.15	.13	— .60	— .60	+ .26	1.25
18..........	8.61	23.65	27.75	10.57	3.94	4.20	2.42	.40	— .60	— .63	.46	1.60
19..........	9.14	20.09	29.70	9.03	3.44	6.18	2.46	.50	— .60	— .78	.52	1.90
20..........	8.53	17.00	37.68	7.81	3.05	6.00	2.24	.40	— .61	— .82	.45	1.70
21..........	7.87	14.45	37.92	6.88	2.91	5.32	2.16	.34	— .64	— .82	.39	1.50
22..........	8.85	12.20	33.55	6.15	2.77	4.91	1.90	.29	— .64	— .84	.38	1.33
23..........	22.47	10.32	29.12	5.56	2.87	4.46	1.71	.22	— .36	— .84	.38	1.20
24..........	29.26	9.13	25.85	5.67	2.90	4.19	2.06	1.06	— .45	— .78	.37	.98
25..........	26.52	8.60	23.54	5.76	2.87	4.04	2.53	.95	— .61	— .80	.37	.92
26..........	22.44	8.35	21.28	5.30	2.97	3.37	2.17	.79	— .64	— .82	.37	.77
27..........	18.55	7.90	18.72	5.26	3.66	2.85	1.70	.77	— .71	— .82	.98	.71
28..........	14.92	7.40	16.35	10.47	3.59	2.69	1.28	1.35	— .76	— .78	.09	.59
29..........	12.14	7.00	14.30	16.06	6.52	2.54	.94	1.30	— .67	— .80	.33	.52
30..........	10.18	......	12.69	14.18	6.50	2.21	.76	.95	— .55	— .80	1.00	.48
31..........	8.88	......	11.40	......	5.78	....	.64	.60	......	— .78	......	.48

The following discharge measurement was made by B. M. Hall in 1897, at Tuscaloosa, Ala.:

January 12, gage height, 1.70 feet; discharge, 829 second-feet.

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1897.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	0.34	3.90	11.14	13.90	9.51	1.83	–0.15	1.36	0.60	–1.65	–1.39	–1.28
2	.47	6.00	9.57	15.28	9.95	1.75	– .18	1.08	.96	–1.71	–1.30	–1.12
3	.40	11.50	8.58	22.20	9.22	1.70	– .20	.87	1.02	–1.72	–1.29	– .48
4	.90	12.60	8.72	21.11	7.66	2.01	– .18	.62	.92	–1.75	–1.31	+1.29
5	1.24	11.70	10.14	22.00	6.23	1.98	– .05	.50	.76	–1.79	–1.33	13.10
6	1.11	12.37	16.33	26.95	5.36	2.65	1.63	.40	.62	–1.86	–1.28	14.24
7	1.40	16.24	51.42	25.32	4.67	3.44	3.40	.25	.51	–1.79	–1.27	10.72
8	2.60	18.70	54.77	22.10	4.20	2.87	3.90	.24	.47	–1.85	–1.27	7.39
9	2.66	21.04	51.59	21.30	3.87	2.25	3.71	1.10	.42	–1.88	–1.17	5.12
10	2.30	19.80	44.69	29.27	3.50	1.85	3.05	2.10	.36	–1.90	–1.13	3.72
11	2.03	17.90	40.54	29.57	3.20	1.60	2.53	3.26	.29	–1.90	–1.10	3.05
12	1.76	23.42	42.53	25.48	3.64	1.39	2.42	3.22	.23	–1.88	–1.14	2.70
13	1.52	25.90	48.70	21.60	11.40	1.24	2.16	2.73	.14	–1.89	–1.17	2.56
14	1.33	23.84	50.96	18.10	20.36	1.11	1.86	2.27	.11	–1.92	–1.25	3.05
15	1.23	20.30	48.57	16.32	20.46	.95	1.46	1.63	.10	–1.92	–1.25	3.54
16	8.23	16.96	45.20	18.43	16.59	.85	1.16	1.28	.06	–1.92	–1.27	4.12
17	9.70	14.04	47.21	18.33	12.68	.75	.97	1.00	.01	–1.90	–1.33	4.10
18	13.10	11.72	46.72	15.92	9.77	.63	1.50	.73	– .05	–1.90	–1.35	3.78
19	19.35	9.97	42.90	13.66	7.73	1.30	3.50	.52	– .36	–1.90	–1.36	3.50
20	18.70	8.77	42.57	11.86	6.35	1.46	12.50	1.53	– .75	–1.88	–1.36	3.82
21	17.43	8.08	44.54	10.45	5.37	1.11	14.50	1.78	– .95	–1.88	–1.36	6.70
22	18.64	8.32	41.50	9.24	4.66	.80	11.30	1.58	–1.07	–1.77	–1.37	10.58
23	16.52	11.00	37.70	8.15	4.13	.55	8.42	1.33	–1.17	–1.64	–1.42	31.00
24	13.30	20.20	35.66	7.37	3.70	.33	6.64	1.08	–1.26	–1.58	–1.44	29.96
25	10.60	21.24	32.40	6.80	3.45	.23	4.77	1.27	–1.24	–1.63	–1.40	24.08
26	8.60	18.97	28.86	6.37	3.13	.16	3.46	.97	–1.36	–1.63	–1.36	18.97
27	7.20	16.18	25.60	5.90	2.90	.12	2.72	.80	–1.41	–1.61	–1.36	15.67
28	6.00	13.31	23.15	5.49	2.60	.03	2.92	.61	–1.44	–1.64	–1.28	13.10
29	5.10	......	20.33	5.10	2.28	.00	2.15	.54	–1.50	–1.61	–1.22	11.00
30	4.42	......	17.52	5.90	2.09	– .08	1.80	.46	–1.55	–1.63	–1.24	9.38
31	3.80	......	14.98	......	2.00	....	1.62	.31	......	–1.63	......	8.00

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1898.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	7.10	21.68	3.67	25.50	11.34	0.23	0.66	2.45	1.20	−0.60	0.90	5.40
2..........	6.28	18.30	3.78	22.40	9.82	.08	.48	1.95	.82	− .70	.70	5 50
3..........	5.52	14.90	4.08	18.50	8.67	.23	.30	2.45	.70	− .80	.60	5.40
4..........	4.96	12.12	4.05	15.31	7.68	.27	.53	2.80	.30	− .90	.40	5.00
5..........	4.41	10.15	3.98	20.82	6.88	.27	.16	2.96	.00	−1.00	.00	4.70
6..........	4.17	9.42	3.90	38.70	6.20	.15	.10	3.90	− .10	− .90	.30	4.50
7..........	4.13	8.90	3.57	38.55	5.59	02	− .18	3.40	− .30	− .90	.50	5.00
8..........	4.18	8.43	3.33	32.83	5.00	−.10	− .04	3.10	− .20	− .70	.40	5.00
9..........	4.17	7.84	3.12	27.70	4.50	−.29	− .04	3.98	.00	− .30	.40	4.70
10..........	3.97	7.30	3.00	23.04	4.20	−.41	+ .10	6.20	.20	+2.00	.50	4 20
11..........	4.00	6.68	2.90	19.50	3.91	−.54	.08	12.20	.40	3.30	.50	3.70
12..........	4.18	6.30	2.83	17.03	3.50	−.62	− .07	14.10	.20	2.60	.40	3.30
13..........	6.70	6.20	2.80	15.01	3.21	−.71	− .10	10.60	.00	2.00	.50	3.00
14..........	9.70	6.08	3.00	12.93	2.88	−.62	− .07	7.30	− .30	1.40	.80	2.80
15..........	11.97	5.86	4.80	11.65	2.58	−.59	− .11	5.00	− .30	1.00	1.10	2.60
16..........	11.71	5.40	8.00	10.78	2.30	−.38	− .07	3.50	− .40	.80	1.30	2.50
17..........	15.00	5.00	15.40	9.60	2.08	−.48	− .14	2.62	− .60	.40	1.50	2 40
18..........	15.53	4.90	14.10	8.63	1.97	−.56	.00	1.91	− .70	.80	1.60	2.10
19..........	14.32	4.83	11.92	8.15	1.64	−.30	1.24	1.50	− .70	.80	1.90	4.40
20..........	24.50	4.84	10.08	27.80	1.43	−.21	1.30	1.46	− .80	1.20	2.20	18.80
21..........	33.54	4.70	8.82	38.11	1.23	.00	1.12	1.12	− .90	3.10	2.50	23.90
22..........	31.42	4.48	7.80	28.45	1.07	.07	.88	1.26	− .50	3.80	4.00	21.30
23..........	28.50	4.30	6.96	23.77	1.00	.18	.47	1.20	− .60	4.10	8.60	17.40
24..........	30.38	4.00	6.30	22.72	.93	.30	1.08	.90	− .70	4.80	11.70	13.30
25..........	30.12	3.83	6.00	24.04	.78	.17	1.95	.50	− .80	4.30	11.60	10.50
26..........	42.50	3.64	5.90	22.62	.57	.06	2.50	1.10	− .90	3.90	9.50	8.60
27..........	43.48	3.[illegible]	5.53	19.67	.43	1.30	2.00	1.02	− .90	2.90	7.40	7.30
28..........	39.41	3.72	5.12	17.12	.43	1.10	1.80	.98	− .80	2.30	5.90	6.20
29..........	33.80	......	5.23	15.05	.52	.46	2.03	1.30	− .80	2.00	5.50	5.60
30..........	28.50	......	13.40	13.03	.44	.68	2.55	1.52	− .60	1.40	5.30	5.00
31..........	24.90	......	25.68	......	.30	.....	2.86	1.56	......	1.10	....	4.70

The following measurements were made by B. M. Hall, and Prof. George S. Wilkins, of the Alabama University, in 1899:

Measurements of Black Warrior River at Tuscaloosa, Ala.

Date.	Gage height.	Discharge.	Date.	Gage height.	Discharge.
February 21..........	19.36	12,855	March 4...............	23.70	12,609
February 21..........	19.25	12,640	March 14..............	31.18	36,653
February 24..........	22.85	16,216	March 14..............	34.37	40,331
February 28..........	39.47	48,010	March 17..............	59.50	119,538
March 1...............	35.50	24,988	March 18..............	56.40	86,410
March 2...............	30.35	18,052	March 23..............	40.30	23,911

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1899.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	4.40	26.10	37.70	30.30	7.90	2.00	0.10	6.50	1.20	—1.50	—1.03	4.83
2	4.50	29.50	32.00	29.20	7.00	1.50	.80	4.90	.70	—1.61	—1.02	3.50
3	4.60	27.00	27.70	24.80	6.30	1.20	.30	3.40	.62	—1.80	—1.03	2.77
4	4.70	29.00	24.10	22.00	5.80	1.00	— .70	2.70	.23	—1.79	— .99	2.03
5	4.70	45.50	21.00	23.20	5.30	1.00	— .10	2.00	— .02	—1.51	—1.00	1.50
6	11.20	50.60	20.80	22.60	4.80	.90	— .30	1.90	— .17	—1.48	—1.02	1.22
7	42.50	51.40	19.50	23.30	4.40	1.00	— .20	1.80	— .38	—1.46	—1.03	.98
8	49.30	51.70	16.90	33.90	4.40	.80	— .30	1.30	— .40	—1.34	—1.03	.88
9	46.60	48.60	14.40	34.00	7.60	.40	— .40	1.20	— .46	—1.30	—1.03	.58
10	40.40	43.10	12.90	30.80	6.50	.40	— .40	1.10	— .68	— .96	—1.01	.60
11	33.70	37.80	11.90	27.00	5.10	.50	— .40	2.00	— .73	— .78	—1.01	2.20
12	31.90	32.80	11.30	23.60	4.30	.50	— .50	1.70	— .79	— .72	— .98	23.50
13	28.00	28.80	10.00	20.10	4.20	.50	— .60	1.30	— .71	— .70	— .96	39.53
14	25.00	25.70	28.80	17.20	4.30	.50	— .60	.90	— .73	— .88	— .98	35.71
15	22.20	22.90	44.50	14.90	4.70	.50	— .70	.60	— .78	— .94	— .99	26.50
16	20.00	21.60	59.30	13.00	4.30	.70	— .70	.40	— .83	—1.03	—1.00	20.63
17	19.60	19.90	60.30	11.60	3.70	.60	— .70	.30	— .86	—1.07	— .97	15.71
18	20.10	20.10	57.70	10.50	3.30	.40	— .70	.30	— .88	—1.12	— .97	10.83
19	18.60	20.80	52.40	9.80	2.80	.30	— .70	.60	— .90	—1.16	— .95	8.02
20	16.10	20.60	49.30	9.60	2.70	.20	— .70	.60	— .92	—1.12	— .95	8.09
21	14.00	19.60	46.80	9.50	3.70	.10	— .60	.70	— .94	—1.10	— .92	9.63
22	12.20	18.50	41.60	8.70	3.80	.40	— .50	1.50	— .99	— .84	— .89	10.80
23	11.00	22.70	36.80	8.60	3.30	—.10	— .20	2.60	—1.03	— .73	— .33	10.63
24	11.00	23.10	33.00	11.30	3.10	—.10	+ .60	2.50	—1.05	— .71	+ .17	22.01
25	20.30	20.90	29.50	13.60	2.70	—.60	4.90	2.60	—1.04	— .88	.88	29.04
26	29.30	18.50	26.50	13.20	2.30	+.20	7.60	2.30	—1.05	— .94	2.60	25.91
27	26.20	23.50	24.20	12.60	2.00	.20	7.40	2.10	—1.04	—1.02	4.50	20.98
28	22.50	39.00	22.30	11.40	1.75	.20	7.90	1.90	—1.18	— .60	10.48	17.09
29	18.60	......	21.10	10.00	1.50	.20	9.50	1.60	—1.28	— .73	9.40	15.10
30	15.70	......	19.30	8.90	1.60	.10	9.30	1.50	—1.38	— .96	6.67	14.62
31	14.80	......	18.10	......	2.50	...	8.50	1.10	......	—1.03	......	12.51

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	10.90	6.92	18.14	21.55	21.23	4.24	41.00	9.85	5.50	0.75	4.20	12.50
2	9.48	6.40	25.44	18.60	18.95	5.30	33.88	8.00	5.00	.80	5.10	9.65
3	8.32	5.00	26.00	15.80	16.33	13.95	32.27	6.50	4.07	.60	5.40	8.50
4	7.10	5.71	23.30	13.60	13.82	15.16	32.13	5.15	4.30	.25	5.55	7.90
5	6.18	6.40	20.29	12.27	11.60	20.98	30.96	4.40	3.58	.40	5.05	8.20
6	5.53	9.58	17.43	12.17	9.60	21.50	27.31	3.80	2.80	.40	4.45	10.20
7	5.12	11.50	15.34	11.44	8.20	20.92	23.70	3.35	2.30	.80	3.90	10.65
8	4.84	10.53	27.58	10.29	7.28	21.75	20.80	3.00	1.90	1.80	3.50	9.65
9	4.60	12.23	39.00	9.97	6.80	28.52	18.45	2.50	1.50	3.90	3.10	8.75
10	4.50	20.60	36.03	10.58	6.50	31.70	15.96	2.30	1.40	6.05	2.90	8.15
11	7.12	23.00	31.63	26.35	6.12	24.73	12.96	2.10	1.10	6.10	2.70	7.50
12	31.63	20.64	27.34	52.79	5.90	19.60	11.05	2.00	.90	14.30	2.50	6.90
13	31.80	41.37	23.78	53.40	5.48	15.95	10.60	1.75	.80	22.50	2.40	6.45
14	28.18	47.96	20.43	48.69	4.98	15.60	12.90	1.50	1.40	21.85	2.25	6.40
15	24.09	45.73	17.40	42.30	4.50	19.23	10.35	1.40	5.45	16.40	2.20	6.65
16	20.12	40.23	16.63	37.10	3.85	29.15	8.50	1.50	10.65	11.60	2.10	6.45
17	16.50	34.74	21.18	63.00	3.65	28.89	7.00	1.48	8.95	8.20	2.05	6.10
18	14.28	29.75	20.28	64.05	3.50	25.33	6.00	1.40	6.34	6.13	2.00	5.75
19	15.80	25.88	18.80	62.17	3.52	24.51	5.60	3.00	4.44	5.10	1.95	5.30
20	25.00	22.43	45.10	59.35	3.39	30.10	6.35	4.40	3.35	4.30	3.90	5.45
21	32.60	19.90	51.00	56.10	3.65	27.80	8.50	3.75	2.60	3.60	8.40	6.30
22	29.44	23.58	47.98	51.71	3.50	25.38	8.00	3.00	2.20	3.15	10.25	8.35
23	24.54	26.50	42.40	46.20	3.35	24.55	8.10	2.50	1.87	4.60	12.50	11.90
24	20.43	24.20	38.24	41.88	4.40	50.00	8.70	2.55	1.65	7.30	11.00	17.00
25	17.12	22.38	35.41	37.94	7.55	58.25	7.40	2.10	1.60	10.40	9.45	18.70
26	14.12	21.00	36.78	33.94	7.68	56.35	6.80	4.48	1.45	8.55	15.90	17.00
27	12.14	18.63	35.33	30.89	6.70	52.90	9.20	4.30	1.30	6.75	22.20	14.00
28	10.47	16.52	31.80	28.15	5.30	49.05	16.20	3.25	1.05	5.40	21.00	12.50
29	9.10	......	28.85	25.73	4.25	48.25	13.50	2.40	.90	4.70	17.35	10.95
30	8.27	......	26.25	23.50	3.60	[illegible]	11.83	2.10	.75	4.10	14.00	10.15
31	7.60	......	24.20	......	3.62	......	11.05	2.50	......	3.70	......	14.20

During 1901 the following discharge measurements were made on Black Warrior River at Tuscaloosa, Ala.:

1901.

Feb. 1—Hydrographer, K. T. Thomas; gage height, 15.10; discharge, 9,300 second-feet.

March 15—Hydrographer, K. T. Thomas; gage height, 18.72; discharge, 9,461 second-feet.

June 27—Hydrographer, K. T. Thomas; gage height, 1.77; discharge, 828 second-feet.

Daily gage height of Black Warrior River at Tuscaloosa, Ala., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	19.50	15.10	7.50	28.00	9.40	6.50	1.70	0.70	6.11	5.40	0.85	1.60
2	19.00	14.80	7.30	26.50	8.50	12.25	1.73	0.60	5.10	6.91	0.80	1.50
3	17.90	15.00	8.40	32.60	7.90	16.65	2.00	0.85	4.05	9.00	0.75	1.40
4	14.70	35.20	9.65	35.10	7.30	14.80	2.20	1.00	3.60	6.72	1.00	1.40
5	13.00	42.00	9.70	31.50	7.00	12.00	2.50	0.80	3.05	5.30	1.10	1.31
6	11.50	38.35	9.50	27.50	6.35	11.20	2.30	0.75	2.81	4.50	1.10	1.95
7	10.25	32.15	9.00	24.30	6.15	11.10	2.50	0.60	2.35	3.45	1.05	1.90
8	9.50	29.15	8.50	20.90	6.00	11.50	2.40	0.50	2.04	3.02	1.00	2.58
9	8.75	28.05	8.05	17.90	5.70	9.40	2.25	0.35	1.90	2.50	0.95	2.60
10	8.30	30.97	8.70	14.50	5.60	7.60	2.10	0.25	1.70	2.31	0.90	3.80
11	17.40	29.75	29.50	12.50	5.00	6.50	2.00	0.20	1.50	2.10	0.90	5.00
12	52.70	27.45	34.00	11.00	4.60	6.20	1.70	0.65	1.41	1.95	0.85	5.80
13	56.50	25.15	28.50	10.00	5.00	6.40	1.30	0.65	1.30	3.41	1.00	5.70
14	53.25	22.50	23.50	11.35	6.60	5.50	0.90	0.80	2.52	3.30	1.05	7.40
15	47.25	19.60	19.70	12.80	8.70	5.05	0.70	1.20	6.70	3.97	1.00	21.00
16	41.45	17.45	16.00	13.00	8.30	4.80	0.60	5.70	8.00	3.80	0.98	40.75
17	36.30	15.70	13.00	11.70	6.80	4.50	0.43	17.00	6.10	3.51	0.90	35.00
18	31.85	13.70	11.05	12.80	5.50	4.10	2.60	26.30	12.21	3.00	0.93	27.00
19	28.15	12.50	10.00	25.70	4.70	3.80	4.00	22.70	16.00	2.70	1.10	21.50
20	25.15	11.90	9.60	39.80	4.90	3.25	5.70	25.70	14.50	2.30	1.30	16.41
21	22.50	10.90	13.00	42.60	8.30	3.00	7.33	32.10	10.60	2.00	1.40	12.10
22	19.85	9.95	16.50	38.00	17.30	2.75	6.00	32.50	7.50	1.81	1.70	9.95
23	17.55	9.20	15.70	32.80	19.80	2.30	4.50	31.97	5.70	1.61	2.00	7.00
24	15.35	8.75	14.00	28.41	17.50	2.20	3.20	26.80	4.51	1.45	2.05	6.80
25	14.60	8.65	13.80	24.40	14.10	2.00	2.50	22.40	3.90	1.31	2.00	7.30
26	18.00	8.50	28.50	21.00	11.30	1.97	2.00	18.30	3.40	1.20	1.95	8.34
27	17.20	8.20	37.25	17.90	9.30	1.85	1.50	14.10	2.91	1.05	1.95	9.00
28	15.50	7.90	34.50	14.90	8.15	1.70	1.05	9.85	2.60	0.81	2.00	10.96
29	14.80	......	29.00	12.50	7.00	1.65	0.90	7.90	2.91	0.55	1.95	[illegible]
30	15.10	......	24.30	10.90	6.90	1.65	0.80	7.41	4.80	0.90	1.91	49.00
31	14.60	......	24.85	......	6.35	......	0.60	7.10	......	0.90	......	42.00

Rating table for Black Warrior River at Tuscaloosa, Ala.

[This table is applicable from Jan. 1, 1895, to Dec. 31, 1901.]

Gage height.	Discharge.	Gage height	Discharge.	Gage height.	Discharge.	Gage height	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
-1.0	90	6.0	3,110	13.0	6,995	20.0	10,880
-0.9	105	6.1	3,160	13.1	7,045	20.1	10,950
-0.8	120	6.2	3,210	13.2	7,095	20.2	11,020
-0.7	140	6.3	3,260	13.3	7,145	20.3	11,090
-0.6	160	6.4	3,310	13.4	7,195	20.4	11,160
-0.5	180	6.5	3,370	13.5	7,255	20.5	11,230
-0.4	200	6.6	3,430	13.6	7,315	20.6	11,305
-0.3	220	6.7	3,490	13.7	7,375	20.7	11,380
-0.2	240	6.8	3,550	13.8	7,435	20.8	11,455
-0.1	260	6.9	3,610	13.9	7,495	20.9	11,530
0.0	280	7.0	3,665	14.0	7,550	21.0	11,600
0.1	310	7.1	3,715	14.1	7,600	21.1	11,690
0.2	340	7.2	3,765	14.2	7,650	21.2	11,780
0.3	370	7.3	3,815	14.3	7,700	21.3	11,870
0.4	400	7.4	3,865	14.4	7,750	21.4	11,960
0.5	430	7.5	3,925	14.5	7,810	21.5	12,050
0.6	460	7.6	3,985	14.6	7,870	21.6	12,140
0.7	490	7.7	4,045	14.7	7,930	21.7	12,230
0.8	530	7.8	4,105	14.8	7,990	21.8	12,320
0.9	565	7.9	4,165	14.9	8,050	21.9	12,410
1.0	600	8.0	4,220	15.0	8,105	22.0	12,500
1.1	635	8.1	4,270	15.1	8,155	22.1	12,600
1.2	670	8.2	4,320	15.2	8,205	22.2	12,700
1.3	710	8.3	4,370	15.3	8,255	22.3	12,800
1.4	750	8.4	4,420	15.4	8,305	22.4	12,900
1.5	790	8.5	4,480	15.5	8,365	22.5	13.000
1.6	830	8.6	4,540	15.6	8,425	22.6	13,100
1.7	870	8.7	4,600	15.7	8,485	22.7	13,200
1.8	910	8.8	4,660	15.8	8,545	22.8	13,300
1.9	955	8.9	4,720	15.9	8,605	22.9	13,400
2.0	1,000	9.0	4,775	16.0	8,660	23.0	13,500
2.1	1,045	9.1	4,825	16.1	8,710	23.1	13,620
2.2	1,090	9.2	4,875	16.2	8,760	23.2	13,740
2.3	1.135	9.3	4,925	16.3	8,810	23.3	13,860
2.4	1,180	9.4	4,975	16.4	8,860	23.4	13,980
2.5	1,225	9.5	5,035	16.5	8.920	23.5	14,100
2.6	1,270	9.6	5,095	16.6	8,980	23.6	14,220
2.7	1.320	9.7	5,155	16.7	9,040	23.7	14,340
2.8	1,370	9.8	5,215	16.8	9,100	23.8	14,460
2.9	1,420	9.9	5,275	16.9	9.160	23.9	14,580
3.0	1,470	10.0	5,330	17.0	9,215	24.0	14,700
3.1	1,520	10.1	5,380	17.1	9,265	24.1	14,830
3.2	1,570	10.2	5,430	17.2	9,315	24.2	14,960
3.3	1,620	10.3	5.480	17.3	9,365	24.3	15,090
3.4	1,670	10.4	5,530	17.4	9,415	24.4	15,200

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
3.5	1,725	10.5	5,590	17.5	9,475	24.5	15,350
3.6	1,780	10.6	5,650	17.6	9,535	24.6	15,480
3.7	1,835	10.7	5,710	17.7	9,595	24.7	15,610
3.8	1,890	10.8	5,770	17.8	9,655	24.8	15,740
3.9	1,945	10.9	5,830	17.9	9,715	24.9	15,870
4.0	2,000	11.0	5,885	18.0	9,770	25.0	16,000
4.1	2,055	11.1	5,935	18.1	9,820	26.0	17,600
4.2	2,111	11.2	5,985	18.2	9,870	28.0	21,500
4.3	2,166	11.3	6,035	18.3	9,920	30.0	26,500
4.4	2,222	11.4	6,085	18.4	9,970	32.0	31,700
4.5	2,277	11.5	6,145	18.5	10,030	34.0	38,000
4.6	2,333	11.6	6,205	18.6	10,090	36.0	45,000
4.7	2,388	11.7	6,265	18.7	10,150	38.0	53,000
4.8	2,444	11.8	6,325	18.8	10,210	40.0	61,000
4.9	2,500	11.9	6,385	18.9	10,270	42.0	69,000
5.0	2,555	12.0	6,440	19.0	10,325	44.0	77,000
5.1	2,610	12.1	6,490	19.1	10,375	46.0	85,000
5.2	2,666	12.2	6,540	19.2	10,425	48.0	93,000
5.3	2,721	12.3	6,590	19.3	10,475	50.0	101,000
5.4	2,777	12.4	6,640	19.4	10,525	52.0	109,000
5.5	2,832	12.5	6,700	19.5	10,585	54.0	117,000
5.6	2,888	12.6	6,760	19.6	10,645	55.0	121,000
5.7	2,943	12.7	6,820	19.7	10,705		
5.8	3,000	12.8	6,880	19.8	10,765		
5.9	3,054	12.9	6,940	19.9	10,825		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Black Warrior River at Tuscaloosa, Alabama.

[Drainage area, 4,900 square miles.]

Month.	Discharge in second-feet.			Total in acre-feet.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-ft. per sq. mile.
1895.						
January	103,400	2,777	25,464	1,565,720	6.00	5.20
February	14,830	4,775	7,603	422,249	1.61	1.55
March	109,000	4,540	39,977	2,458,106	9.42	8.16
April	14,700	3,665	6,895	410,280	1.57	1.41
May	13,860	2,000	5,511	338,860	1.29	1.12
June	3,665	1,000	2,133	126,922	0.49	0.44
July	9,970	1,000	3,581	220,189	0.84	0.73
August	2,500	565	1,098	67,514	0.25	0.22
September	1,835	310	883	52,542	0.20	0.18
October	310	140	233	14,327	0.06	0.05
November	750	280	488	29,038	0.11	0.10
December	11,600	530	2,021	124,267	0.47	0.41
1896.						
January	24,610	2,444	5,981	367,757	1.41	1.22
February	47,000	3,665	19,161	1,102,153	4.22	3.91
March	52,600	3,160	12,996	799,093	3.06	2.65
April	14,100	2,721	6,072	361,309	1.38	1.24
May	49,800	1,370	7,420	456,238	1.74	1.51
June	9,970	1,090	2,910	173,157	0.65	0.59
July	4,420	460	1,232	75,753	0.29	0.25
August	750	310	478	29,391	0.12	0.10
September	400	120	201	11,960	0.04	0.04
October	260	120	157	9,654	0.03	0.03
November	600	120	307	18,268	0.07	0.06
December	4,045	430	955	58,721	0.22	0.19
1897.						
January	10,500	385	3,493	214,775	0.82	0.71
February	17,440	1,945	8,409	467,010	1.79	1.72
March	120,080	4,540	52,883	3,251,650	12.44	10.79
April	25,285	2,610	9,657	574,630	2.20	1.97
May	11,195	1,000	3,600	221,355	0.84	0.73
June	1,697	260	715	42,545	0.17	0.15
July	7,810	240	1,809	111,230	0.43	0.37
August	1,595	355	701	43,100	0.16	0.14
September	600	102	295	17,555	0.07	0.06
October	102	90	93	5,718	0.02	0.02
November	125	107	115	6,843	0.03	0.02
December	29,000	115	5,549	341,195	1.30	1.13
1898.						
January	75,000	1,972	16,577	1,019,287	3.90	3.38
February	12,230	1,752	3,902	216,706	0.83	0.80

Estimated monthly discharge of Black Warrior River at Tuscaloosa, Alabama.

[Drainage area, 4,900 square miles.]

Month.	Discharge in second-feet.			Total in acre-ft.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-ft. per sq. mile.
March	17,120	1,370	3,626	222,955	0.85	0.74
April	55,800	4,295	15,620	929,452	3.56	3.19
May	6,060	370	1,766	108,589	0.41	0.36
June	710	160	303	18,030	0.07	0.06
July	1,395	250	549	33,757	0.13	0.11
August	7,600	430	1,785	109,756	0.41	0.36
September	670	140	252	14,995	0.06	0.05
October	2,444	130	880	54,109	0.21	0.18
November	6,265	280	1,626	96,754	0.37	0.33
December	14,580	1,045	3,763	231,379	0.89	0.77
1899.						
January	81,375	2,222	18,118	1,114,033	4.27	3.70
February	90,375	10,030	30,923	1,717,376	6.57	6.31
March	122,625	5,330	35,308	2,171,004	8.31	7.21
April	32,800	4,540	11,901	708,158	2.71	2.43
May	4,165	790	2,092	128,632	0.49	0.43
June	1,000	175	448	26,658	0.10	0.09
July	5,035	160	1,111	68,313	0.26	0.23
August	3,370	370	963	59,213	0.23	0.20
September	670	110	200	11,901	0.04	0.04
October	175	92	130	7,993	0.03	0.03
November	5,590	127	721	42,902	0.17	0.15
December	47,650	460	8,880	546,010	2.09	1.81
1900.						
January	29,760	2,277	9,857	606,083	2.01	2.32
February	76,312	2,555	18,356	1,019,440	3.75	3.90
March	87,750	8,280	27,105	1,666,623	5.53	6.37
April	136,687	5,302	48,426	2,881,547	9.88	11.02
May	11,825	1,645	3,702	227,627	0.76	0.88
June	115,312	2,138	32,614	1,940,668	6.66	7.43
July	52,000	2,888	10,952	673,412	2.24	2.59
August	5,245	750	1,674	102,930	0.34	0.39
September	5,680	512	1,580	94,017	0.32	0.36
October	13,000	355	3,382	207,951	0.69	0.80
November	12,700	977	3,701	220,225	0.76	0.85
December	10,150	2,721	5,119	314,755	1.05	1.21
The year	136,687	355	13,872	9,955,278	2.83	38.12

Estimated monthly discharge of Black Warrior River at Tuscaloosa, Alabama.

[Drainage area, 4.900 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
January	108,375	4,370	22,938	4.68	5.39
February	55,100	4,165	15,094	3.08	3.21
March	40,900	3,815	11,947	2.44	2.81
April	57,020	5,330	17,370	3.55	3.96
May	10,765	2,333	4,355	.89	1.03
June	9,010	850	3,217	.66	.74
July	3,815	415	1,210	.25	.29
August	29,550	340	7,117	1.45	1.67
September	8,660	710	2,626	.54	.60
October	4,775	445	1,536	.31	.36
November	1,022	512	712	.15	.17
December	80,250	710	13,293	2.71	3.12
The year	108,375	340	8,454	1.73	23.35

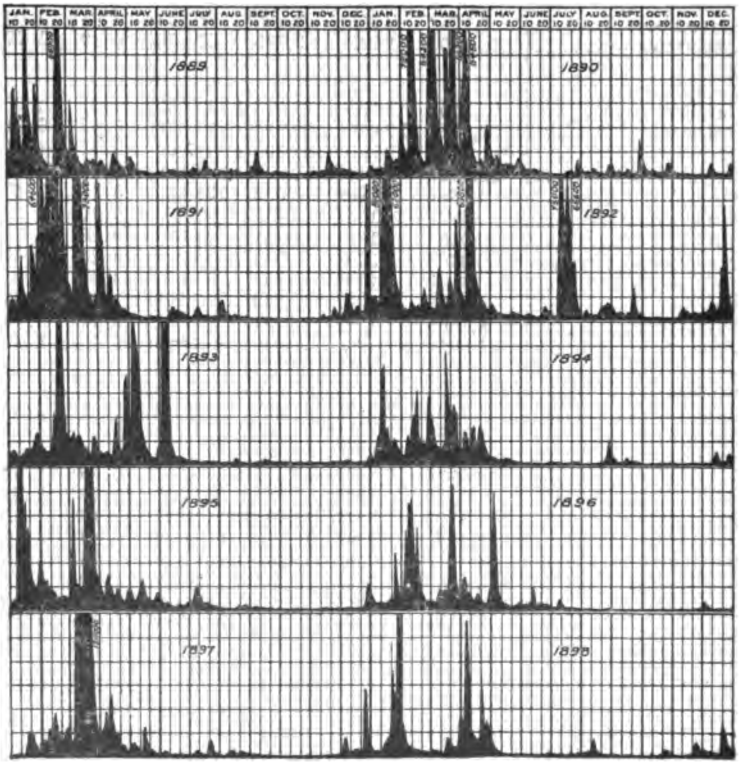

FIG. 14.—Discharge of Black Warrior River at Tuscaloosa, Alabama, 1889-1898.

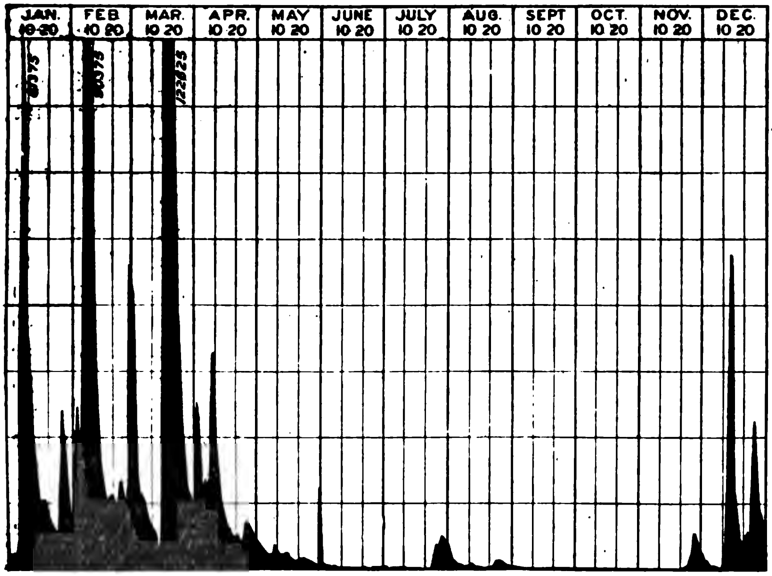

FIG. 15.—Discharge of Black Warrior River at Tuscaloosa, Alabama, 1899.

Minimum monthly discharge of Black Warrior River at Tuscaloosa, Ala., with corresponding net horse power per foot of fall on a water wheel realizing 80 *per cent. of the theoretical power.*

[Drainage area, 4,900 square miles.]

	1899			1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January	2,222	202	1	2,277	207	1	4,370	398	1
February	10,030	912	2	2,555	232	1	4,165	378	1
March	5,330	485	1	8,282	753	1	3,815	347	1
April	4,539	413	1	5,302	483	1	5,330	485	1
May	790	72	1	1,645	150	1	2,333	212	1
June	175	16	1	2,138	194	1	850	77	2
July	160	15	7	2,888	262	1	415	38	1
August	370	34	2	750	68	2	340	31	1
September	110	10	1	512	47	1	710	65	1
October	92	9	1	355	32	1	445	40	1
November	127	12	5	977	89	1	512	47	1
December	460	42	1	2,721	247	1	710	65	1

2. BLACK WARRIOR RIVER NEAR CORDOVA, ALABAMA.

This station is located at the Kansas City, Memphis & Birmingham Railroad bridge, three-fourths of a mile from Cordova, Alabama. The gage was established by the United States Weather Bureau, but the records were discontinued by that bureau some time ago. From 12 to 55 feet the gage is a vertical timber bolted to the inside of the bridge pier on the left bank of the river. Below 12 feet the gage was sloping, but it was out of position, and could not be used when the station was established by the Geological Survey on May 21, 1900, so a short new section was put in at that time. This section is a 2-inch by 10-inch plank, graduated to feet and tenths, marked with nails from —1.5 feet to +12.5 feet, and spiked to a willow tree on the right bank of the river about 200 feet below the bridge. The bench mark is the top of the stone pier on the left bank, and is 54.95 feet above the zero of the gage. Measurements are made from the railroad bridge, which is a single-span, iron, through bridge 300 feet long. The section is a good one. The observer is A. B. Logan, who lives on the right bank of the river, only a few hundred feet from the end of the bridge. During 1900 measurement was made by Max Hall as follows:

Daily gage height, in feet, of Black Warrior River near Cordova, Alabama, for 1900.

Day	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec
1	......	0.6	8.1	0.9	0.5	—0.8	—0.1	1.4
2	......	2.8	5.2	.5	.2	— .8	+ .5	1.0
3	......	5.3	7.1	.4	.1	— .9	.8	.8
4	......	7.1	6.5	.2	.0	— .9	.4	1.0
5	......	7.5	5.3	.1	— .1	—1.0	.3	1.9
6	......	7.6	4.6	.0	— .2	—1.0	.3	1.8
7	......	6.5	3.5	.1	— .3	—1.1	.2	1.4
8	......	7.3	2.1	.2	— .4	+ .2	.2	1.2
9	......	6.5	2.5	.3	— .5	.9	.1	1.0
10	......	4.5	2.7	.3	— .5	.9	.0	.8
11	......	3.2	1.0	.4	— .6	.1	— .1	.7
12	......	3.0	.8	.5	— .6	9.4	— .2	.7
13	......	4.6	1.0	.5	— .7	9.2	— .2	.8
14	......	8.6	.8	.5	— .6	3.2	— .3	.8
15	......	9.8	.5	.6	1.5	2.3	— .3	.8
16	......	8.0	.4	.6	.9	1.7	— .3	.6
17	......	8.2	.4	.6	.5	1.0	— .4	.5
18	......	7.2	.3	.6	.1	.6	+ .3	.4
19	......	13.4	.3	.1	.0	.3	.2	.4
20	......	10.0	.2	.0	— .1	.2	.1	.5
21	0.1	6.1	.7	.2	— .2	.1	.3	1.5
22	.1	6.5	1.0	.3	— .3	.0	1.1	3.0
23	.1	15.2	.8	.4	— .3	1.0	.8	2.9
24	1.5	32.9	.5	.8	— .4	.7	.8	5.0
25	1.5	33.8	.9	1.7	— .4	.5	.9	4.0
26	1.0	31.3	.5	.8	— .5	.3	5.1	3.1
27	.6	22.1	1.6	.2	— .5	.2	4.9	2.5
28	.7	23.9	2.4	.0	— .6	.1	3.6	2.1
29	.8	22.4	1.3	.1	— .7	.0	2.8	1.8
30	.9	16.5	1.2	.9	— .7	— .1	1.9	1.7
31	.9	....	1.5	1.0	......	— .1	......	2.8

During 1901 the following discharge measurements were made on Black Warrior River at Cordova, Alabama:

1901.

Jan. 8—Hydrographer, Max Hall; gage height, 1.30; discharge, 1,781 second-feet.

Feb. 18—Hydrographer, K. T. Thomas; gage height, 2.40; discharge, 2,863 second-feet.

March 12—Hydrographer, K. T. Thomas; gage height, 9.45; discharge, 13,279 second-feet.

April 17—Hydrographer, K. T. Thomas; gage height, 1.70; discharge, 2,024 second-feet.

June 20—Hydrographer, K. T. Thomas; gage height, 0.00; discharge, 644 second-feet.

Oct. 26—Hydrographer, K. T. Thomas; gage height, —0.40; discharge, 385 second-feet.

Daily gage height, in feet, of Black Warrior River near Cordova, Alabama, for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	3.7	4.00	1.00	5.40	1.7	1.6	+0.1	—0.6	0.7	1.2	—0.4	— 0.2
2..........	3.1	3.60	1.60	9.20	1.5	4.5	0.3	—0.6	0.5	0.8	—0.5	— 0.2
3..........	2.8	4.50	2.30	14.50	1.3	2.8	0.1	—0.65	0.4	0.5	—0.5	— 0.1
4..........	2.5	17.60	1.90	10.90	1.1	2.1	0.0	—0.65	0.2	0.4	—0.4	0.0
5..........	2.3	18.00	1.60	7.00	1.0	2.0	—0.2	—0.70	0.1	0.3	—0.4	0.1
6..........	2.0	9.10	1.80	5.80	0.8	2.6	—0.2	—0.70	0.0	0.2	—0.4	0.1
7..........	1.7	5.60	1.50	4.90	0.7	2.7	—0.3	—0.70	—0.1	0.1	—0.3	0.1
8..........	1.5	5.20	1.30	4.20	0.6	[illegible]	—0.3	—0.65	—0.2	0.0	—0.3	0.1
9..........	1.3	7.10	1.50	3.50	0.5	1.5	—0.4	—0.60	—0.3	—0.1	—0.4	0.1
10..........	2.6	8.10	17.50	2.80	0.4	1.1	—0.5	—0.60	—0.4	—0.2	—0.4	0.7
11..........	19.9	6.20	20.50	2.30	0.3	2.2	—0.6	—0.60	—0.5	—0.2	—0.4	1.2
12..........	32.5	5.40	10.80	2.10	0.4	1.5	—0.6	—0.30	—0.3	—0.2	—0.3	1.0
13..........	29.85	4.80	6.20	1.80	0.6	1.1	—0.6	+ .40	—0.3	0.0	—0.3	0.8
14..........	17.85	4.20	5.30	2.50	3.1	1.0	—0.7	.10	+0.5	+1.1	—0.3	6.2
15..........	9.25	3.80	4.20	2.80	1.8	0.9	—0.7	.20	0.7	0.6	—0.3	2.4
16..........	6.80	3.30	3.50	2.30	1.3	0.7	—0.7	5.00	0.5	0.3	—0.4	1.52
17..........	5.50	2.90	2.80	1.80	0.9	0.6	—0.6	12.10	3.8	0.1	—0.4	8.1
18..........	4.30	2.60	2.20	2.20	0.7	0.5	0.0	6.80	5.0	0.0	—0.4	5.3
19..........	3.80	2.20	1.90	9.40	0.9	0.3	+1.1	10.80	3.5	—0.1	—0.2	3.5
20..........	3.10	2.00	2.40	16.10	1.8	0.2	2.8	8.70	1.8	—0.2	0.0	2.6
21..........	2.80	1.80	5.00	11.50	5.8	0.0	1.6	8.50	1.1	—0.2	—0.1	2.0
22..........	2.60	1.60	4.20	6.80	7.3	—0.1	0.5	11.20	0.8	—0.3	—0.1	1.5
23..........	2.40	1.30	3.50	5.40	5.5	—0.2	0.0	7.30	0.5	—0.3	0.0	1.5
24..........	2.60	1.40	3.50	4.50	3.6	—0.3	—0.2	5.20	0.4	—0.4	—0.1	2.0
25..........	5.40	1.20	4.95	3.60	2.8	—0.3	—0.3	4.00	0.3	—0.4	—0.2	2.5
26..........	5.00	1.20	11.20	3.00	2.1	—0.3	—0.4	2.80	0.2	—0.4	—0.2	2.1
27..........	3.80	1.10	6.90	2.60	1.6	—0.4	—0.5	2.00	0.1	—0.4	—0.1	2.6
28..........	4.20	1.00	5.30	2.20	1.3	—0.4	—0.5	1.50	0.1	—0.4	—0.1	5.0
29..........	3.80	......	4.60	2.00	1.1	—0.4	—0.5	1.40	1.0	—0.5	—0.2	18.5
30..........	3.60	......	4.00	1.90	1.0	—0.5	—0.55	1.20	2.3	—0.5	—0.2	22.0
31..........	4.20	......	6.20	......	1.0	.....	—0.6	1.00	......	—0.5	.....	13.5

Rating table for Black Warrior River at Cordova, Alabama, for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Sec. ft.*	*Feet.*	*Second ft.*	*Feet*	*Second ft.*
—0.7	205	3.3	4,144	7.3	10,064	11.3	15,984
—0.6	260	3.4	4,292	7.4	10,212	11.4	16,132
—0.5	320	3.5	4,440	7.5	10,360	11.5	16,280
—0.4	384	3.6	4,588	7.6	10,508	11.6	16,428
—0.3	450	3.7	4,736	7.7	10,656	11.7	16,576
—0.2	518	3.8	4,884	7.8	10,804	11.8	16,724
—0.1	588	3.9	5,032	7.9	10,952	11.9	16,872
0.0	660	4.0	5,180	8.0	11,100	12.0	17,020
0.1	734	4.1	5,328	8.1	11,248	12.1	17,168
0.2	810	4.2	5,476	8.2	11,396	12.2	17,316
0.3	888	4.3	5,624	8.3	11,544	12.3	17,464
0.4	968	4.4	5,772	8.4	11,692	12.4	17,612
0.5	1,050	4.5	5,920	8.5	11,840	12.5	17,760
0.6	1,134	4.6	6,068	8.6	11,988	12.6	17,908
0.7	1,220	4.7	6,216	8.7	12,136	12.7	18,056
0.8	1,307	4.8	6,364	8.8	12,284	12.8	18,204
0.9	1,396	4.9	6,512	8.9	12,432	12.9	18,352
1.0	1,486	5.0	6,660	9.0	12,580	13.0	18,500
1.1	1,577	5.1	6,808	9.1	12,728	13.1	18,648
1.2	1,669	5.2	6,956	9.2	12,876	13.2	18,796
1.3	1,762	5.3	7,104	9.3	13,024	13.3	18,944
1.4	1,856	5.4	7,252	9.4	13,172	13.4	19,092
1.5	1,951	5.5	7,400	9.5	13,320	13.5	19,240
1.6	2,047	5.6	7,548	9.6	13,468	13.6	19,388
1.7	2,144	5.7	7,696	9.7	13,616	13.7	19,536
1.8	2,242	5.8	7,844	9.8	13,764	13.8	19,684
1.9	2,342	5.9	7,992	9.9	13,912	13.9	19,832
2.0	2,444	6.0	8,140	10.0	14,060	14.0	19,980
2.1	2,547	6.1	8,288	10.1	14,208	14.1	20,128
2.2	2,652	6.2	8,436	10.2	14,356	14.2	20,276
2.3	2,758	6.3	8,584	10.3	14,504	14.3	20,424
2.4	2,868	6.4	8,732	10.4	14,652	14.4	20,572
2.5	2,988	6.5	8,880	10.5	14,800	14.5	20,720
2.6	3,118	6.6	9,028	10.6	14,948	14.6	20 868
2.7	3,258	6.7	9,176	10.7	15,096	14.7	21,016
2.8	3,404	6.8	9,324	10.8	15,244	14.8	21,164
2.9	3,552	6.9	9,472	10.9	15,392	14.9	21,312
3.0	3,700	7.0	9,620	11.0	15,540	15.0	21,460
3.1	3,848	7.1	9,768	11.1	15,688		
3.2	3,996	7.2	9,916	11.2	15,836		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Mulberry Fork of Black Warrior River, near Cordova, Alabama.

[Drainage area, 237 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1900.					
June	49,284	1,134	16,185	8.52	9.51
July	11,248	810	2,975	1.57	1.81
August	2,144	660	1,016	.53	.61
September	1,951	205	556	.29	.32
October	13,098	60	1,732	.91	1.05
November	6,808	384	1,487	.78	.87
December	6,660	968	2,154	1.18	1.30
1901.					
January	51,800	1,762	8,713	4.59	5.29
February	31,820	1,486	6,616	3.48	3.62
March	29,600	1,486	6,637	3.49	4.02
April	23,088	2,242	6,967	3.67	4.10
May	10,064	968	2,539	1.34	1.54
June	5,920	320	1,582	.83	.93
July	3,404	205	631	.33	.38
August	17,168	205	4,155	2.19	2.53
September	6,660	320	1,415	.74	.83
October	1,669	320	687	.36	.42
November	660	320	468	.25	.28
December	31,820	518	4,923	2.59	2.99
The year	51,800	205	3,778	1.99	26.93

Minimum monthly discharge of Black Warrior River at Cordova, Ala., with corresponding net horse power per foot of fall on a water wheel realizing* 80 *per cent. of the theoretical power.

[Drainage area, 237 square miles.]

	1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.
January	......	......	....	1,762	160	1
February	......	......	....	1,486	135	1
March	......	......	....	1,486	135	1
April	......	......	....	2,242	201	2
May	734	67	3	968	88	1
June	1,134	103	1	320	29	1
July	810	74	1	205	19	3
August	660	60	3	205	19	3
September	205	19	3	320	29	1
October	60	55	1	320	29	3
November	384	35	1	320	29	2
December	968	88	2	518	47	2

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

3. SURVEY OF BLACK WARRIOR RIVER, ALABAMA.

The Black Warrior River is formed by the junction of the Mulberry and Sipsey forks of Black Warrior at Old Warrior Town in Walker County, Alabama, and runs in a southwesterly direction past Tuscaloosa to Demopolis, Ala., at which point it enters the Tombigbee River. Above Tuscaloosa it is known as the Black Warrior River, and below Tuscaloosa as the Warrior River.

The accompanying profile is made from the surveys of the Corps of Engineers, U. S. A.

A great deal of work is being done by the Government on this river in order to make it navigable as an outlet to important coal fields above.

In the 92 miles from Old Warrior Town to Tuscaloosa, there is a fall of 158 feet. The distribution of this fall is shown by the following table, giving distances in miles above Tuscaloosa and elevations of water surface above sea level.

Miles above Tuscaloosa.	Elevation above sea level.	
92.4	249.7	Fork of Sipsey and Mulberry.
85.3	248.8	Black Water Creek.
84.6	242.3	Foot of Sanders Shoals.
79.7	242.1	Big Cane Creek.
76.2	240.8	Above Paynes Mill.
76.2	237.1	Below Paynes Mill.
74.4	231.7	Foot of Bee Shoals.
71.2	231.6	Birch Shoals.
71.2	230.6	Birch Shoals.
69.0	230.0	Top of Tuggles Shoals.
68.0	225.6	Foot of Tuggles Shoals.
55.0	216.6	Mouth of Lost Creek.
48.0	215.1	Mouth of Little Warrior River.
47.6	206.1	Foot of Fork Shoals.
43.3	296.1	Above Knight's Mill.
43.3	202.5	Below Knight's Mill.
38.0	202.2	Above Black Rock.
37.7	193.0	Below Black Rock.
30.3	192.3	Top of Squaw Shoals.
25.8	151.3	Foot of Squaw Shoals.
21.7	139.8	Foot of Fair Shoals.
19.3	132.3	Foot of Rose Shoals.
8.7	132.30	Top of Lock 4, at Lower Yellow Creek.
2.0	120.16	Top of Lock 3, Tuscaloosa, Ala.
1.3	109.66	Top of Lock 2, Tuscaloosa, Ala.
0.7	101.16	Top of Lock 1, Tuscaloosa, Ala.
	91.30	Foot of Lock 1, Tuscaloosa, Ala.

There are gage stations, both at Tuscaloosa and Cordova, Ala., where systematic discharge measurements have been made, the results of which are given in the foregoing pages. Comparative measurements at the two stations at same stage, which was same stage as low water in November, 1901, shows a discharge of 825 second-feet at Tuscaloosa, and 285 second-feet at Cordova. At minimum stage of dryest years the water gets considerably lower, as is shown by the records referred to, but the figures named are safe for low season in all ordinary years, and will be used in this discussion, for determining the power available at different sites along the river.

The locks and proposed locks on this section of the river begin with No. 1, at Tuscaloosa, and are numbered up the river. Locks 1, 2, 3 and 4 are about completed, and others are projected, but the locations of the latter in the following list are approximated. However, the exact location of each is immaterial in showing the power available. The following is a table showing positions of locks and lock sites in miles above Tuscaloosa, the sea level elevation of water below each, the lift at each and the net horsepower that can be developed at each day on an 80 per cent. turbine during dry season in ordinary years, like 1900, after deducting 100 second-feet for lockage.

No. of, lock or site.	Miles from Tuscaloosa.	Sea-level elevation of water below lock.	Lift.	Sec.-ft. after deducting 100 for lockage.	Net H. P. on 80 per cent. turbine without storage.	Location.
1	0.7	91.30	9.86	725	650	Bottom University Shoal, Tuscaloosa.
2	1.3	101.16	8.50	725	560	On University Shoal, Tuscaloosa.
3	2.0	109.66	10.50	725	690	On University Shoal, Tuscaloosa.
4	8.7	120.16	12.14	704	777	Near mouth of Yellow Creek.
5	19.3	132.30	10.00	660	600	Foot of Rose Shoals.
6	21.7	142.30	9.00	660	540	Foot of Fair Shoals.
7	25.8	151.30	14.00	660	840	Foot of Squaw Shoals.
8	26.3	165.30	14.00	660	840	On Squaw Shoals.
9	27.8	179.30	14.00	660	840	On Squaw Shoals.
10	37.7	193.3	14.00	550	700	Below Black Rock.
11	47.6	207.3	14.00	550	700	Mouth of Little Warrior River, or Locust Fork.
12	63.4	221.3	14.00	374	476	
13	75.0	235.3	14.00	285	364	

The best power on the river is at Squaw Shoals, 26 miles above Tuscaloosa, covered on the above table by locks Nos. 7, 8 and 9, each having a lift of 14 feet, and making a total fall on Squaw Shoals of 42 feet. This can be developed to best advantage by constructing a canal from the top of proposed dam at Lock No. 9, along the river bank, two miles in length, to a point opposite the foot of Squaw Shoals, below Lock No. 7. This canal taking the river water not need for lockage, and allowing two feet for grade and storage, will utilize a net head of 40 feet, and produce 2,400 net horse power continuously, or 4,800 net horse power for a 12-hour run per day, storing the water above Lock No. 9 during the 12 idle hours.

It is to be remembered that the above estimates of power are for low season during ordinary years. There will be exceptional periods of minimum water in extremely dry years in which the entire flow of the river will be as low as 100 second-feet, and will, therefore, barely suffice for lockage during a busy season of boating on the river. See Nineteenth Annual Report, United States Geological Survey, Part IV, page 251. But such seasons are rare, and the facilities for water transportation should compensate for them to a great extent. It is admitted that the cheapness of coal along this river would naturally make the water powers less valuable, but the cheapness of development in connection with Government dams would partly offset the cheapness of coal. It is believed that the proposed development at Squaw Shoals could be made at a very moderate cost, and that such an investment would pay handsomely.

APPENDIX TO BLACK WARRIOR REPORT.

The following additional information concerning the Warrior and Black Warrior River is from Mr. R. C. McCalla, U. S. Assistant Engineer, Tuscaloosa, Ala., who is in charge of the improvements on that river.

Tuscaloosa is 361 miles by river above Mobile, and above here the river is called the Black Warrior, and below it is called the Warior. The locks on the two parts of the stream are numbered as two separate systems, the lowest lock in each system being No. 1, and the numbers running up stream. The following table gives the lift and location of the locks in both systems:

No. of lock.	Lift in feet.	Miles above Mobile.		
1	10.00	230.5	....	0.5 miles below mouth of Warrior; located but not begun.
2	10.00	246.2	....	Located but not begun.
3	10.00	266.7	....	Located but not begun.
4	10.00	282.3	....	Under construction.
5	10.00	298.3	....	Under construction.
6	10.00	315.2	....	Under construction.
1	9.86	361.9	....	In operation.
2	8.60	362.3	....	In operation.
3	10.60	363.1	....	In operation.
4	12.14	370.1	....	Under construction.

Between Lock No. 4 and the junction of Mulberry and Locust Forks, 407.8 miles above Mobile, there are projected seven locks at 14 feet lift each, but none of these are yet located. The following table gives the location, etc., of gages now established and read daily at 7 A. M.:

Name of Gauge.	No. of gauges.	Miles above Mobile.	Elevation of zero above mean low tide, Mobile.	Remarks.
Demopolis	1	229.7	28.07	Zero. about 1¼ ft. above mean low water.
Millwood	1	259.8	45.97	Zero about mean low water.
Lock 4.........	1	282.3	54.50	Zero top of lower mitre sill.
A. G. S. bdge	1	288.0	61.26	Zero about mean low water.
Lock 5.........	1	298.3	64.50	Zero top of lower mitre sill.
Lock 6.........	1	315.2	74.50	Zero top of lower mitre sill.
Grays Landg.	1	319.5	80.41	Zero about mean low water.
Tuscaloosa ...	1	361.1	86.86	Zero about 1 ft. above mean low water.
Lock 1.........	2	361.9	84.36	Zero top of lower mitre sill.
Lock 2.........	2	362.3	94.36	Zero top of lower mitre sill.
Lock 3.........	2	363.1	102.86	Zero top of lower mitre sill.
Lock 4.........	1	370.1	113.36	Zero top of lower mitre sill.
Cordova	1	445.0	237.[illegible]5	Zero about mean low water.

5. BLACK WARRIOR RIVER TRIBUTARIES.

At Clear Creek Falls, in Winston County, within a distance of half a mile, there is a fall of over 100 feet, distributed as follows:

Rapids above Upper Falls in 100 yards................	6 feet fall
Upper Falls, about	45 feet fall
Still pool for 275 yards	00 feet fall
Lower Falls	27 feet fall
Rapids below Lower Falls	30 feet fall

No discharge measurements have ever been made on this stream. It is thought best not to attempt to approximate its flow by any water-shed rule, as the stream originates from big springs. Actual discharge measurements will be made during 1902.

Little Warrior, or Locust Fork, is an important stream on which no surveys have been made. On December 1, 1901, a hydrographic station was established on this stream at Palos, Ala., by Mr. R. C. McCalla, U. S. Assistant Engineer, and will be maintained by him.

Mr. B. M. Hall and his assistants will make a series of discharge measurements at this station during 1902. The only measurement so far was on January 18, 1902. The gage stood at 0.85, and the discharge was 849 second-feet.

There are other tributaries having shoals that can be developed, but they have not been examined.

CHAPTER VI.

1. TOMBIGBEE RIVER AT COLUMBUS, MISSISSIPPI.

This station is located about 1,000 feet below the highway bridge, 1½ miles from the Southern Railway depot at Columbus. The rod, which is in three sections, is fastened vertically to the rock bluff on the left bank. It is a 3-inch by 10-inch pine timber 45 feet long, marked with brass figures and copper nails, the graduation extending from —5.0 feet to +40.0 feet. The initial point of sounding is the end of the iron bridge, right bank, downstream side. Bench mark No. 1 is 250 feet from the initial point of sounding. The bridge floor is 40.85 feet above the zero of the rod, and the top of the iron girder under the floor timbers is 39.85 feet above the zero. Bench mark No. 2 is the top of the rail at the depot of the Southern Railway, and is 55.2 feet above gage datum and 190.9 feet above mean sea level. The width of the river at low water is 160 feet. The maximum record height of the river was on April 8, 1892, when the gage registered 42 feet. The lowest recorded height was on October 26, 1893, when the gage reading was —3.9 feet. The danger line is at 33 feet. No measurements of discharge were made during 1900.

Daily gage height in feet of Tombigbee River at Columbus, Miss., for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	3.5	0.4	7.1	4.5	8.0	1.0	19.7	5.8	— 1.2	— 2.7	+ 2.6	+ 3.4
2	2.2	.3	6.8	3.8	6.5	8.0	18.3	4.0	— 1.0	— 2.8	+ 4.9	+ 2.5
3	1.8	.2	5.6	2.7	5.9	10.0	17.6	2.8	— 1.0	— 3.0	+ 5.5	+ 1.9
4	1.6	.4	4.4	1.9	4.5	13.4	16.2	1.9	— .7	— 3.1	+ 5.1	+ 1.0
5	1.4	1.8	3.8	1.5	2.8	15.3	15.9	1.0	— .6	— 3.3	+ 4.4	+ .1
6	1.2	3.5	3.4	1.3	1.5	17.0	15.4	.0	— .9	— 3.5	+ 3.1	+ .2
7	1.1	3.5	7.6	1.3	.8	20.7	14.5	— .5	— 1.3	— 3.5	+ 1.9	+ .3
8	1.0	3.3	14.4	1.1	.5	23.6	13.5	— .9	— 1.9	— 2.2	+ .9	+ .3
9	.9	4.2	15.1	.7	1.4	25.5	10.0	— 1.4	— 2.1	— 1.0	— .1	.0
10	.9	8.4	13.8	.5	2.3	25.0	6.8	— 1.8	— 2.3	— .6	— .5	— .3
11	2.0	7.8	11.3	11.7	3.3	23.6	5.5	— 2.2	— 2.4	— .4	— .9	+ .5
12	6.6	7.6	9.9	16.2	3.6	21.6	4.0	— 2.6	— 2.5	+ 2.6	— 1.1	— .6
13	8.3	10.2	6.7	17.4	2.8	20.0	3.5	— 2.6	— 2.6	+ 4.8	— 1.3	+ .9
14	7.1	9.8	4.3	19.3	2.2	18.5	2.0	— 2.7	— 2.7	+ 5.2	— 1.3	+ .9
15	5.6	8.1	4.8	20.8	1.6	17.8	1.9	— 2.2	— 2.7	+ 5.6	— 1.4	+ .9
16	4.6	5.8	5.6	20.5	+ .7	17.1	1.5	— 2.2	— 2.8	+ 5.4	— 1.5	+ .9
17	2.8	4.6	5.2	22.9	.0	17.3	1.0	— 2.3	— 2.9	+ 2.4	— 1.5	+ .9
18	2.4	3.8	4.6	26.9	— .4	17.8	.5	— 2.3	— 3.0	+ .4	— 1.6	— 1.0
19	2.2	3.2	9.4	27.6	— 1.0	18.0	.0	— 1.8	— 3.0	— .4	— 1.6	— 1.0
20	2.1	2.8	15.6	27.5	— .8	16.8	.4	— 1.4	— 3.1	— .9	— 1.6	— 1.0
21	1.9	3.5	18.2	27.1	— .5	15.2	1.3	— 1.1	— 3.0	— 1.1	— 1.6	— 1.0
22	1.8	5.6	19.0	25.5	— .5	13.5	2.0	— 1.6	— 2.9	— 1.3	+ 1.2	+ 3.8
23	1.6	5.4	19.2	23.3	+ .1	13.8	1.9	— 1.9	— 2.7	— 1.0	.0	+ 5.0
24	1.4	4.5	18.1	21.3	.2	18.5	1.4	— 2.0	— 1.3	— .2	+ 1.7	+ 6.0
25	1.2	5.0	15.2	19.4	.3	21.5	.7	— .1	— 1.7	+ .8	+ 2.3	+ 6.6
26	1.1	5.0	11.4	17.3	2.3	24.1	.1	+ 1.2	— 2.0	+ 1.0	+ 2.8	+ 6.8
27	.9	3.9	7.8	14.8	2.4	25.0	1.8	+ .6	— 2.2	+ 5.1	+ 3.3	+ 6.1
28	.7	4.2	4.6	11.8	2.2	24.8	5.0	— .3	— 2.4	+ 5.6	+ 3.8	+ 5.0
29	.6	......	3.9	9.5	1.6	23.5	7.2	— 1.1	......	+ 3.0	......	+ 4.0
30	.5	......	3.1	9.4	1.0	21.7	5.9	— 1.0	— 2.5	+ 4.6	+ 3.9	+ 4.2
31	.4	......	3.3	......	.8	....	6.7	— 1.4	— 2.5	+ 4.0	+ 3.8	+ 4.8

The following discharge measurements were made during 1901 by K. T. Thomas:

March 11—Gage height, 12.33 feet; discharge, 19,425 second-feet.
April 16—Gage height, 1.10 feet; discharge, 3,926 second-feet.
June 25—Gage height, —2.50; discharge, 698 second-feet.
Oct. 30—Gage height, —3.00; discharge, 657 second-feet.

Daily gage height in feet of Tombigbee River at Columbus, Miss., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.0	6.0	0.9	2.6	0.9	1.8	— 1.6	— 3.2	— 0.4	— 2.3	— 3.0	— 2.2
2	3.7	5.9	0.8	6.4	0.5	3.1	— 2.4	— 3.4	— 0.9	— 2.0	— 3.0	— 2.2
3	3.2	6.8	2.2	8.0	0.2	3.8	— 2.4	— 3.5	— 1.3	— 2.2	— 3.0	— 2.3
4	2.6	12.3	2.4	7.1	0.0	3.9	— 2.1	— 3.4	— 1.6	— 2.2	— 2.9	— 2.3
5	1.8	13.2	2.1	6.8	— 0.3	3.5	— 2.4	— 3.3	— 1.6	— 2.5	— 2.9	— 2.2
6	1.0	13.9	1.8	6.2	— 0.5	3.1	— 1.6	— 3.2	— 1.9	— 2.5	— 2.9	— 2.2
7	0.7	15.1	1.4	5.3	— 0.6	2.8	— 2.6	— 3.0	— 2.0	— 2.6	— 3.0	— 2.2
8	0.1	15.9	1.2	4.0	— 0.9	1.9	— 2.6	— 2.8	— 2.2	— 2.7	— 2.8	— 2.1
9	0.0	15.6	1.0	2.9	— 1.0	1.4	— 2.7	— 2.8	— 2.3	— 2.7	— 2.8	— 2.0
10	0.3	14.5	8.8	2.0	— 1.1	1.0	— 2.8	— 2.9	— 2.4	— 2.8	— 2.8	— 1.8
11	10.9	13.0	12.1	1.4	— 1.2	—0.1	— 2.8	— 2.9	— 2.5	— 2.8	— 2.7	— 1.1
12	16.9	12.5	14.0	0.9	— 1.2	—0.7	— 2.9	— 3.1	— 2.5	— 2.8	— 2.8	— 0.5
13	19.4	12.4	17.8	0.7	— 0.4	—1.0	— 3.0	— 3.0	— 2.4	— 2.6	— 2.8	+ 0.1
14	21.7	11.0	19.4	0.7	+ 3.3	—0.9	— 3.1	— 3.2	— 2.1	— 2.5	— 2.8	4.5
15	22.7	8.9	19.0	0.9	4.4	—0.8	— 3.1	— 1.5	— 1.8	— 2.2	— 2.8	9.5
16	22.3	6.0	17.1	1.2	4.4	—0.8	— 3.2	+ 4.0	— 1.0	— 2.0	— 2.7	9.8
17	20.9	4.4	13.8	1.5	3.6	—0.8	— 3.2	11.5	— 0.2	— 2.0	— 2.7	9.2
18	18.8	3.3	10.8	6.0	2.7	—1.0	— 3.0	12.4	+ 2.5	— 2.2	— 2.7	9.8
19	16.0	2.7	8.0	11.8	2.1	—1.2	— 3.0	12.4	3.4	— 2.3	— 2.6	10.0
20	13.6	2.2	6.3	12.4	2.1	—1.7	— 3.0	14.0	3.5	— 2.4	— 2.5	8.8
21	9.4	1.8	4.6	12.7	6.3	—2.0	— 2.0	15.6	2.6	— 2.5	— 2.4	5.9
22	6.2	1.5	3.5	13.5	6.7	—2.2	— 1.9	15.9	1.4	— 2.6	— 2.2	4.8
23	3.8	1.2	3.2	13.5	6.3	—2.4	— 2.3	14.8	0.4	— 2.7	— 2.3	2.4
24	3.0	1.0	3.1	11.8	5.3	—2.5	— 2.5	12.1	— 0.6	— 2.8	— 2.1	1.4
25	5.9	1.0	2.8	8.2	4.0	—2.5	— 2.6	8.9	— 1.2	— 2.9	— 2.0	0.8
26	6.5	1.1	2.5	5.1	2.2	—2.6	— 2.9	6.5	— 1.6	— 2.9	— 1.9	0.7
27	6.3	1.2	2.2	3.4	1.5	—2.6	— 3.0	4.1	— 1.9	— 2.9	— 1.8	1.1
28	6.0	1.0	1.9	2.5	1.8	—2.6	— 3.1	2.0	— 2.1	— 2.9	— 1.8	1.0
29	5.8	......	1.6	1.8	1.7	—2.7	— 3.2	1.6	— 2.2	— 3.0	— 2.0	9.0
30	5.7	......	1.4	1.3	1.2	—2.6	— 3.3	1.1	— 2.3	— 3.0	— 2.1	11.0
31	5.5	......	2.3	......	0.9	.....	— 3.4	0.3	......	— 3.0	......	9.6

Rating table for Tombigbee River at Columbus, Miss., for 1900 and 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
—3.0	650	1.0	3,790	5.0	9,310	9.0	14,830
—2.9	668	1.1	3,928	5.1	9,448	9.1	14,968
—2.8	688	1.2	4,066	5.2	9,586	9.2	15,106
—2.7	712	1.3	4,204	5.3	9,724	9.3	15,244
—2.6	736	1.4	4,342	5.4	9,862	9.4	15,382
—2.5	752	1.5	4,480	5.5	10,000	9.5	15,520
—2.4	780	1.6	4,618	5.6	10,138	9.6	15,658
—2.3	810	1.7	4,756	5.7	10,276	9.7	15,796
—2.2	842	1.8	4,894	5.8	10,414	9.8	15,934
—2.1	877	1.9	5,032	5.9	10,552	9.9	16,072
—2.0	915	2.0	5,170	6.0	10,690	10.0	16,210
—1.9	956	2.1	5,308	6.1	10,828	10.1	16,348
—1.8	1,000	2.2	5,446	6.2	10,966	10.2	16,486
—1.7	1,047	2.3	5,584	6.3	11,104	10.3	16,624
—1.6	1,097	2.4	5,722	6.4	11,242	10.4	16,762
—1.5	1,150	2.5	5,860	6.5	11,380	10.5	16,900
—1.4	1,206	2.6	5,998	6.6	11,518	10.6	17,038
—1.3	1,265	2.7	6,136	6.7	11,656	10.7	17,176
—1.2	1,328	2.8	6,274	6.8	11,794	10.8	17,314
—1.1	1,394	2.9	6,412	6.9	11,932	10.9	17,452
—1.0	1,464	3.0	6,550	7.0	12,070	11.0	17,590
—0.9	1,537	3.1	6,688	7.1	12,208	11.5	18,280
—0.8	1,613	3.2	6,826	7.2	12,346	12.0	18,970
—0.7	1,692	3.3	6,964	7.3	12,484	12.5	19,660
—0.6	1,775	3.4	7,102	7.4	12,622	13.0	20,350
—0.5	1,863	3.5	7,240	7.5	12,760	13.5	21,040
—0.4	1,957	3.6	7,378	7.6	12,898	14.0	21,730
—0.3	2,057	3.7	7,516	7.7	13,036	14.5	22,420
—0.2	2,165	3.8	7,654	7.8	13,174	15.0	23,110
—0.1	2,283	3.9	7,792	7.9	13,312	15.5	23,800
0.0	2,410	4.0	7,930	8.0	13,450	16.0	24,490
0.1	2,548	4.1	8,068	8.1	13,588	16.5	25,180
0.2	2,686	4.2	8,206	8.2	13,726	17.0	25,870
0.3	2,824	4.3	8,344	8.3	13,864	17.5	26,560
0.4	2,962	4.4	8,482	8.4	14,002	18.0	27,250
0.5	3,100	4.5	8,620	8.5	14,140	18.5	27,940
0.6	3,238	4.6	8,758	8.6	14,278	19.0	28,630
0.7	3,376	4.7	8,896	8.7	14,416	19.5	29,320
0.8	3,514	4.8	9,034	8.8	14,554	20.0	30,010
0.9	3,652	4.9	9,172	8.9	14,692		

Estimated monthly discharge of Tombigbee River at Columbus, Miss.
[Drainage area, 4,440 square miles.]

Month	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Depth in inches.	Second feet per square mile.
1900.					
January	13,864	2,962	5,588	1.26	1.45
February	16,486	2,686	8,659	1.95	2.03
March	23,938	6,688	15,285	3.42	3.85
April	40,498	3,100	21,265	4.79	5.34
May	13,450	1,464	4,944	1.11	1.28
June	37,600	37,90	27,692	6.24	6.96
July	29,596	2,410	11,411	2.57	2.97
August	10,414	707	2,257	.51	.59
September	1,775	632	950	.21	.23
October	10,138	566	3,989	.90	1.04
November	10,000	1,097	4,304	.97	1.08
December	11,794	1,464	5,239	1.18	1.36
The year	40,498	566	9,299	2.09	28.18
1901.					
January	33,736	2,410	14,193	3.20	3.69
February	24,352	3,790	12,533	2.83	2.95
March	29,182	3,514	10,884	2.45	2.33
April	21,040	3,376	9,890	2.23	2.49
May	11,656	1,328	4,949	1.11	1.28
June	7,792	707	2,767	.62	.69
July	10,97	582	730	.16	.18
August	24,352	582	7,673	1.73	1.99
September	7,240	753	2,008	.45	.50
October	915	650	748	.17	.20
November	1,000	650	756	.17	.19
December	17,590	810	6,730	1.52	1.75
The year	33,736	582	6,155	1.39	18.74

Minimum monthly discharge of Tombigbee River at Columbus, Miss., with corresponding net horse power per foot of fall on a water wheel realizing 80 *per cent, of the theoretical power.*

[Drainage area, 4,440 square miles.]

	1900			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot fall.	No. of days duration of minimum.
January	2,962	269	1	2,410	219	1
February	2,686	244	1	3,790	345	3
March	6,688	608	1	3,514	319	1
April	3,100	282	1	3,376	307	2
May	1,464	133	1	1,328	121	2
June	3,790	345	1	707	65	1
July	2;410	219	1	582	53	1
August	707	65	1	582	53	1
September	632	57	1	753	68	2
October	566	51	2	650	59	3
November	1,097	100	4	650	59	4
December	1,464	133	4	810	74	2

NOTE.—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the to.. fall of the shoal by the "Net H. P. per foot of fall" in this table for that month.

2. TOMBIGBEE RIVER NEAR EPES, ALABAMA.

A record of gage heights has been kept at this station for the last ten years by the Alabama Great Southern Railway Company. The gage is painted on the center brick pier of the railway bridge of that company across the Tombigbee a half mile east of Epes, and is referred to two bench marks, the first, the top of the iron girder at the third cross-beam at the station, 80 feet from the right-bank end of the iron bridge, is 64.70 feet above datum of gage; the second, the top of the cross-tie or the base of the rail at the station, 80 feet from the right-bank end of he iron bridge, is 65.50 feet above datum of gage. The west bank of the river is a solid wall of limestone, the east bank is flat and is subject to overflow. The trestle at the east end of the bridge is seven-eighths of a mile long. The section is good, though the water is very deep and rather swift.

Daily gage height in feet of Tombigbee River near Epes, Ala., for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	8.5	3.0	18.0	24.5	43.0	6.0	44.5	14.5	2.0	0.5	7.0	8.0
2	7.5	3.0	19.0	19.5	41.0	8.0	44.5	12.0	2.5	.5	8.0	7.5
3	6.5	3.0	18.0	16.0	39.0	15.0	44.5	10.5	2.0	.5	9.0	7.0
4	6.0	3.0	17.0	12.0	33.5	21.0	44.0	8.0	2.0	.5	8.5	6.0
5	5.5	5.0	15.0	10.0	28.0	24.5	42.5	6.0	2.0	.5	8.5	5.0
6	5.0	6.0	14.0	8.0	20.5	27.0	42.0	5.0	2.0	.5	7.5	4.5
7	4.5	7.0	13.0	7.5	16.0	29.5	41.0	5.0	2.0	.5	7.0	4.0
8	4.0	7.5	18.0	7.5	10.0	32.0	40.0	4.0	2.0	.5	5.5	4.0
9	3.5	11.5	21.0	7.0	7.0	34.5	39.0	3.0	2.0	.5	4.5	4.0
10	3.5	13.5	23.0	6.5	7.0	37.0	38.0	2.0	2.0	2.0	4.0	3.5
11	13.0	15.0	24.0	20.5	7.0	38.5	34.0	2.0	1.5	4.0	4.0	3.0
12	20.0	20.5	24.0	26.0	8.0	39.5	26.0	2.0	1.5	6.0	3.0	3.0
13	23.0	26.0	23.0	29.0	8.0	40.5	23.0	2.0	1.5	7.5	3.0	3.5
14	23.5	28.0	20.0	30.0	7.0	41.0	15.5	2.0	2.0	8.5	2.5	3.5
15	22.0	28.0	17.5	31.0	6.0	41.5	13.0	2.0	1.5	10.0	2.0	3.5
16	21.0	26.0	17.0	38.0	6.0	42.0	8.0	1.5	1.0	10.5	2.0	3.0
17	18.5	24.0	18.0	46.0	5.0	42.0	7.0	1.5	1.0	10.0	2.0	3.0
18	15.0	22.0	18.0	48.5	4.0	42.0	6.0	1.5	1.0	7.5	2.0	3.0
19	11.5	18.5	18.5	51.0	3.5	41.5	5.0	1.5	1.0	5.0	2.5	3.0
20	10.0	16.0	26.0	51.5	3.5	41.5	6.5	1.5	.5	4.0	2.5	6.0
21	8.5	14.0	30.0	52.0	3.5	41.5	7.0	1.0	.5	3.5	3.0	5.0
22	8.0	15.0	32.0	52.0	3.5	41.0	8.0	1.0	.5	3.0	3.5	5.0
23	8.0	17.5	34.0	51.5	3.5	41.0	9.0	2.0	.5	2.0	3.5	8.5
24	7.0	18.0	35.5	51.0	4.0	42.5	8.0	1.5	.5	2.0	3.5	10.0
25	6.5	[illegible]	37.5	49.5	4.5	42.5	6.0	1.5	.5	3.0	6.5	11.5
26	6.0	17.0	38.0	47.5	5.0	43.5	5.5	1.5	.5	4.0	8.5	11.5
27	5.0	16.0	39.0	47.0	6.0	43.5	5.0	5.0	.5	4.5	7.5	12.5
28	3.0	17.0	38.5	46.5	7.0	43.5	5.5	4.5	.5	7.5	7.5	12.0
29	3.0	......	35.0	46.0	7.0	44.0	14.0	4.0	.5	9.0	8.0	10.0
30	3.0	......	33.0	44.5	6.0	44.5	14.5	3.0	.5	8.0	8.5	10.0
31	3.0	......	30.0	......	5.0	....	14.5	2.0	......	7.5	......	10.5

The following discharge measurements were made during 1901 by K. T. Thomas:

Jan. 31—Gage height, 12.70 feet; discharge, 13,738 second-feet.
March 14—Gage height, 21.10 feet; discharge, 23,824 second-feet.
June 28—Gage height, 1.00 feet; discharge, 1,496 second-feet.
Nov. 13—Gage height, 0.70 feet; discharge, 1,290 second-feet.

Daily gage height in feet of Tombigbee River near Epes, Ala., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	10.0	12.0	6.5	13.0	7.5	5.5	1.0	......	5.5	1.5	0.7	1.7
2	10.0	10.5	6.5	13.5	7.0	6.0	1.0	......	4.0	6.0	0.7	1.7
3	9.0	16.8	9.0	15.5	6.0	7.0	1.0	......	3.5	2.5	0.7	1.7
4	8.0	21.5	9.0	18.0	5.0	9.0	1.0	......	2.5	1.5	0.0	3.5
5	7.0	25.5	8.5	17.0	4.5	9.0	1.0	......	2.0	1.5	0.0	2.0
6	6.0	26.5	7.0	16.0	5.0	11.0	1.0	......	2.0	1.5	0.0	2.0
7	5.5	27.5	6.5	15.0	4.0	12.0	1.0	......	1.5	1.5	0.0	2.0
8	5.0	29.0	6.5	14.0	3.5	10.0	1.0	......	1.5	1.0	0.0	3.5
9	4.5	30.5	6.5	11.0	3.5	8.0	1.0	......	1.5	1.0	0.7	5.9
10	4.0	31.0	13.0	9.5	3.0	6.5	1.0	......	1.5	1.0	0.7	6.5
11	18.0	31.0	18.0	8.0	3.0	5.5	0.5	......	1.5	1.0	0.7	5.5
12	29.5	31.0	19.5	7.5	3.5	4.5	0.5	......	1.5	1.0	0.7	4.7
13	33.0	30.0	20.0	9.0	4.0	4.0	0.5	......	1.0	1.0	0.7	4.2
14	35.0	29.5	24,5	8.0	7.0	3.5	0.5	......	1.0	1.0	0.7	13.0
15	36.0	28.5	25.5	7.0	8.0	3.5	0.5	......	1.0	1.0	0.7	19.5
16	38.0	26.0	26.5	7.0	8.5	3.5	0.5	8.5	1.5	1.0	0.7	22.0
17	39.0	23.0	26.5	6.5	8.0	3.0	0.5	15.0	2.0	1.0	1.0	23.0
18	39.5	16.0	26.0	20.0	7.0	3.0	0.5	20.0	2.5	1.0	1.7	22.5
19	40.0	12.0	25.0	28.0	6.5	2.5	0.5	22.5	6.0	1.0	1.7	22.0
20	40.5	1.00	23.0	29.5	9.0	2.0	1.0	23.0	......	1.0	1.5	20.0
21	39.0	8.5	20.0	30.0	12.0	2.0	1.0	24.0	7.5	1.0	1.5	18.0
22	38.0	8.0	17.0	29.5	12.0	2.0	1.0	24.5	7.5	1.0	1.7	14.0
23	34.5	7.5	12.5	28.5	11.5	1.5	1.0	26.0	7.0	1.0	1.7	12.0
24	29.0	7.0	11.0	28.0	11.0	1.2	1.0	26.5	5.5	0.5	1.8	9.0
25	24.5	6.5	12.0	27.0	10.0	1.0	1.0	26.0	4.0	0.5	1.8	8.0
26	20.0	6.5	13.5	24.0	8.0	1.0	1.0	25.0	3.0	0.5	2.0	7.0
27	16.0	6.5	13.5	18.0	6.[illegible]	1.0	0.5	23.0	2.0	0.5	2.0	7.0
28	15.0	6.5	11.5	13.0	6.5	1.0	0.5	19.0	1.5	0.5	2.0	12.0
29	14.0	......	10.0	11.0	6.5	1.0	−0.2	12.0	1.5	0.5	1.9	20.0
30	13.0	......	9.0	8.0	6.5	1.0	−0.2	6.5	1.5	0.5	1.8	26.0
31	12.7	......	13.5	......	7.0	....	−0.2	5.5	......	0.5	......	27.0

Rating table for Tombigbee River at Epes, Ala., for 1900-1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet.*	*Second-ft.*
—0.2	810	5.4	5,208	11.0	11,700	16.6	18,420
—0.1	840	5.5	5,308	11.1	11,820	16.7	18,540
0.0	880	5.6	5,409	11.2	11,940	16.8	18,660
0.1	830	5.7	5,511	11.3	12,060	16.9	18,780
0.2	985	5.8	5,613	11.4	12,180	17.0	18,900
0.3	1,043	5.9	5,716	11.5	12,300	17.1	19,020
0.4	1,103	6.0	5,820	11.6	12,420	17.2	19,140
0.5	1,164	6.1	5,925	11.7	12,540	17.3	19,260
0.6	1,226	6.2	6,030	11.8	12,660	17.4	19,380
0.7	1,289	6.3	6,136	11.9	12,780	17.5	19,500
0.8	1,353	6.4	6,243	12.0	12,900	17.6	19,620
0.9	1,418	6.5	6,350	12.1	13,020	17.7	19,740
1.0	1,484	6.6	6,458	12.2	13,140	17.8	19,860
1.1	1,551	6.7	6,566	12.3	13,260	17.9	19,980
1.2	1,619	6.8	6,675	12.4	13,380	18.0	20,100
1.3	1,688	6.9	6,785	12.5	13,500	18.1	20,220
1.4	1,758	7.0	6,900	12.6	13,620	18.2	20,340
1.5	1,829	7.1	7,020	12.7	13,740	18.3	20,460
1.6	1,903	7.2	7,140	12.8	13,860	18.4	20,580
1.7	1,976	7.3	7,260	12.9	13,980	18.5	20,700
1.8	2,050	7.4	7,380	13.0	14,100	18.6	20,020
1.9	2,125	7.5	7,500	13.1	14,220	18.7	20,940
2.0	2,200	7.6	7,620	13.2	14,340	18.8	21,060
2.1	2,276	7.7	7,740	13.3	14,460	18.9	21,180
2.2	2,353	7.8	7,860	13.4	14,580	19.0	21,300
2.3	2,431	7.9	7,980	13.5	14,700	19.1	21,420
2.4	2,510	8.0	8,100	13.6	14,820	19.2	21,540
2.5	2,590	8.1	8,220	13.7	14,940	19.3	21,660
2.6	2,671	8.2	8,340	13.8	15,060	19.4	21,780
2.7	2,753	8.3	8,460	13.9	15,180	19.5	21,900
2.8	2,835	8.4	8,580	14.0	15,300	19.6	22,020
2.9	2,918	8.5	8,700	14.1	15,420	19.7	22,140
3.0	3,002	8.6	8,820	14.2	15,540	19.8	22,260
3.1	3,087	8.7	8,940	14.3	15,660	19.9	22,380
3.2	3,172	8.8	9,060	14.4	15,780	20.0	22,500
3.3	3,258	8.9	9,180	14.5	15,900	20.1	22,620
3.4	3,345	9.0	9,300	14.6	16,020	20.2	22,740
3.5	3,432	9.1	9,420	14.7	16,140	20.3	22,860
3.6	3,520	9.2	9,540	14.8	16,260	20.4	22,980
3.7	3,609	9.3	9,660	14.9	16,380	20.5	23,100
3.8	3,698	9.4	9,780	15.0	16,500	20.6	23,220
3.9	3,788	9.5	9,900	15.1	16,620	20.7	23,340
4.0	3,878	9.6	10,020	15.2	16,740	20.8	23,460
4.1	3,969	9.7	10,140	15.3	16,860	20.9	23,580
4.2	4,060	9.8	10,260	15.4	16,980	21.0	23,700

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second-ft.*	*Feet.*	*Second-ft.*	*Feet*	*Second-ft.*	*Feet.*	*Second-feet.*
4.3	4,152	9.9	10,380	15.5	17,100	21.1	23,820
4.4	4,245	10.0	10,500	15.6	17,220	21.2	23,940
4.5	4,338	10.1	10,620	15.7	17,340	21.3	24,060
4.6	4,432	10.2	10,740	15.8	17,460	21.4	24,180
4.7	4,527	10.3	10,860	15.9	17,580	21.5	24,300
4.8	4,622	10.4	10,980	16.0	17,700	21.6	24,420
4.9	4,718	10.5	11,100	16.1	17,820	21.7	24,540
5.0	4,815	10.6	11,220	16.2	17,940	21.8	24,660
5.1	4,912	10.7	11,340	16.3	18,060	21.9	24,780
5.2	5,010	10.8	11,460	16.4	18,180	22.0	24,900
5.3	5,109	10.9	11,580	16.5	18,300		

NOTE.—This table applied to the foregoing "Daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Tombigbee River at Epes, Ala.

[Drainage area, 8,830 square miles.]

Month.	Discharge in second-feet.			Run-off.	
	Maximum.	Minimum.	Mean.	Second-feet per square mile.	Depth in inches.
1901.					
January	47,100	3,878	25,579	2.90	3.34
February	35,700	6,350	20,999	2.38	2.48
March	30,300	6,350	16,198	1.83	2.11
April	34,500	6,350	18,102	2.05	2.29
May	12,900	3,002	6,880	.78	.90
June	12,900	1,484	4,585	.52	.58
July	1,484	810	1,295	.15	.17
August 16-31	....	....	21,541	2.44	1.41
September	7,500	1,484	3,205	.36	.40
October	5,820	1,164	1,633	.18	.21
November	2,200	880	1,550	.18	.20
December	30,900	1,960	12,249	1.39	1.60

Minimum monthly discharge of Tombigbee River at Epes, Ala., with corresponding net horse-power per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.

[Drainage area, 8,830 square miles.]

	1900.			1901.		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot fall.	No. of days duration of minimum.
January	3,002	273	4	3,878	353	1
February	3,002	273	4	6,350	577	4
March	14,100	1,282	1	6,350	577	5
April	6,350	577	1	6,350	577	1
May	3,432	312	5	3,002	273	2
June	5,820	529	1	1,484	135	6
July	4,815	438	2	810	74	3
August	1,484	135	2	......	......	....
September	1,164	106	11	1,484	135	3
October	1,164	106	9	1,164	106	8
November	2,200	200	4	880	80	5
December	3,002	273	5	1,960	178	3

NOTE—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "net H. P. per foot of fall" in this table for that month.

3. TRIBUTARIES.

There are several large creeks in Marion and Lamar Counties that flow into Mississippi, and enter the Tombigbee River near Columbus. One of these, the Buttahatchee Creek, in Marion County, has numerous rapids, especially near the crossing of the Military Road.

Luxapalila Creek, in Lamar County, has two prongs that are both good power streams. They come together before the creek enters Mississippi, making Big Luxapalila Creek, which enters the Tombigbee at Columbus, Miss. The following measurements have been made on this stream at Columbus, Miss.:

1901.

March 11—Gage height, 8.20 feet; discharge, 2,459 second-feet.
April 16—Gage height, 4.45 feet; discharge, 873 second-feet.
June 26—Gage height, 1.90 feet; discharge, 109 second-feet.
Oct. 31—Gage height, 2.00 feet; discharge, 126 second-feet.

CHAPTER VII.

1. TENNESSEE RIVER AT CHATTANOOGA, TENNESSEE.

This river, after passing Chattanooga, enters Alabama. It then makes a bend to the west and later to the north, returning to Tennessee. Flowing through this State and Kentucky, it empties into the Ohio 50 miles above Cairo. In 1879 a gage was established at Chattanooga, Tennessee, at the foot of Lookout street, just below Chattanooga Island, by the Signal Corps of the United States Army, which has been in charge of the Weather Bureau since July 1, 1891. The drainage area above this station is 21,382 square miles, and is mapped on Morristown, Greenville, Roan Mountain, London, Knoxville, Mount Guyot, Asheville, Murphy, Briceville, Standingstone, Wartburg, Pikeville, Maynardville, Cumberland Gap, Jonesville, Estillville, Bristol, Whitesburg, Grundy, Abington, Tazewell, Pocahontas, Wytheville, Cranberry, Morganton, Mount Mitchell, Saluda, Pisgah, Como, Nantahala, Walhalla, Dahlonega, Ellijay, Dalton, Cleveand, Ringgold, Kingston, and Chattanooga atlas sheets. The gage is on an incline railroad iron for about 20 feet of its lower portion. Above this it is a vertical rod, bolted to the rock bluff forming the river bank. The zero of the gage is 630.4 feet above sea level. Measurements are made from the Hamilton County steel highway bridge at the foot of Walnut street, a short distance below the gage. Gage heights are obtained from L. M. Pindell, United States Weather Bureau observer. During the year 1900 a new gage on the same datum was established. It is a vertical rod bolted to the south side of the third stone pier from the south end of the bridge.

Daily gage height of Tennessee River at Chattanooga, Tenn, for 1890.

[Furnished by L. M. Pindell, observer in charge, United States Weather Bureau.]

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1..........	4.9	8.0	40.2	10.0	7.5	6.1	3.2	5.8	7.6	9.4	6.8	2.4
2..........	5.2	7.3	42.5	9.8	7.1	6.6	2.9	5.2	5.6	8.1	6.6	2.4
3..........	5.1	7.3	41.0	9.4	6.7	5.3	2.9	4.7	5.7	7.7	5.7	2.3
4..........	5.0	7.4	34.4	9.7	6.8	5.3	3.0	4.7	4.0	7.2	5.3	2.3
5..........	5.0	7.2	23.0	12.2	7.0	5.2	3.0	4.8	3.6	6.4	5.0	2.8
6..........	4.8	7.8	15.1	14.0	7.5	5.3	3.0	4.5	3.2	5.7	4.6	2.5
7..........	4.7	8.3	14.2	13.6	8.9	5.2	3.0	5.2	3.6	5.2	4.4	2.8
8..........	4.6	11.5	14.4	13.4	9.1	4.9	2.9	5.7	3.2	5.2	4.3	2.9
9..........	4.7	19.3	12.8	11.9	8.7	4.7	2.8	6.6	2.8	5.5	4.0	7.1
10..........	4.9	20.4	11.2	10.5	8.7	4.5	2.7	7.5	2.8	5.3	3.9	8.1
11..........	4.7	17.8	10.0	9.6	8.1	4.5	2.7	7.2	3.0	4.8	3.8	8.2
12..........	4.6	14.7	9.2	8.7	7.7	4.4	3.0	6.3	3.4	4.6	3.6	7.7
13..........	4.6	12.0	8.6	8.0	7.2	4.0	2.7	5.8	3.6	4.4	3.5	7.4
14..........	4.9	10.0	8.7	7.5	6.7	3.9	2.5	5.2	4.6	4.2	3.4	6.4
15..........	4.6	9.8	9.7	7.1	6.6	4.0	2.3	4.8	4.0	3.9	3.3	3.7
16..........	5.4	9.6	13.7	6.9	7.8	4.1	2.1	4.2	4.0	3.7	3.2	4.2
17..........	7.2	9.0	15.1	7.1	9.3	4.0	2.0	3.8	3.7	3.7	3.2	3.9
18..........	9.2	9.3	14.9	9.4	8.6	3.9	2.2	3.7	4.0	3.7	3.0	3.9
19..........	8.2	8.5	13.0	16.6	7.9	3.7	4.7	3.3	5.3	4.2	3.2	4.0
20..........	7.5	7.8	11.7	20.4	8.8	3.6	4.7	3.1	3.7	4.0	3.1	4.0
21..........	7.0	7.3	12.4	18.2	10.7	3.7	4.1	2.6	3.7	4.0	3.1	3.9
22..........	9.6	7.1	14.0	14.3	11.9	3.8	3.5	2.5	5.8	3.8	3.1	3.9
23..........	13.0	7.2	20.0	11.3	11.9	3.7	3.2	3.8	3.5	5.3	2.9	3.9
24..........	12.3	7.4	25.5	9.6	11.6	3.8	3.2	4.0	3.3	7.2	2.8	3.9
25..........	11.7	12.1	27.2	8.7	9.2	4.0	4.1	3.3	3.4	8.8	2.8	4.3
26..........	10.0	18.7	26.0	8.4	7.8	4.0	5.9	3.8	4.0	9.2	2.7	4.6
27..........	8.3	26.4	21.4	8.4	7.4	3.9	7.5	3.6	4.3	9.5	2.6	9.4
28..........	7.3	34.8	15.4	8.5	8.0	3.9	7.7	3.0	4.0	8.6	2.6	12.5
29..........	6.6	......	13.0	8.4	8.1	3.5	7.0	3.8	3.8	7.6	2.5	12.9
30..........	7.7	......	11.9	8.1	7.4	3.1	6.3	5.4	5.3	7.1	2.4	12.4
31..........	8.3	......	10.7	......	6.8	....	6.2	6.5	......	7.0	......	9.3

Daily gage height of Tennessee River at Chattanooga, Tenn. for 1891.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	7.7	9.8	18.6	15.4	5.9	5.8	3.9	8.3	5.4	1.8	1.3	3.7
2..........	7.8	13.2	17.5	16.3	5.7	5.6	3.8	10.3	4.7	1.9	1.3	3.2
3..........	9.9	16.1	15.6	16.3	5.6	5.3	3.6	15.1	4.3	1.9	1.3	2.9
4..........	14.1	19.8	13.3	15.7	5.5	4.8	3.6	16.4	4.2	1.8	1.2	2.8
5..........	15.5	22.6	15.4	15.1	5.2	4.4	3.6	12.0	5.1	1.8	1.2	5.6
6..........	15.2	21.6	20.0	12.6	5.1	4.1	3.6	8.7	5.1	1.7	1.2	6.1
7..........	10.4	18.3	23.6	11.6	4.9	3.9	3.4	6.9	5.2	1.7	1.2	6.6
8..........	8.2	16.9	29.1	10.8	4.7	4.1	3.4	5.8	5.2	1.6	1.2	8.6
9..........	7.1	14.5	34.5	9.8	4.6	4.6	3.3	5.1	5.8	1.7	1.2	10.8
10..........	6.3	21.0	37.5	9.6	4.5	4.7	4.5	4.6	4.9	1.7	1.2	10.9
11..........	6.5	27.8	38.9	9.8	4.4	5.5	5.1	4.4	4.4	1.8	1.5	10.3
12..........	8.9	34.3	37.6	9.9	4.3	7.0	4.4	4.0	3.9	1.8	1.7	8.5
13..........	10.7	36.5	33.5	10.6	4.2	6.5	3.9	4.0	3.6	1.7	2.7	6.8
14..........	10.0	37.5	27.0	11.3	4.1	5.7	3.5	3.9	3.5	1.7	3.6	5.7
15..........	9.2	35.5	22.2	12.2	4.2	5.5	3.1	3.8	3.5	1.7	4.1	5.1
16..........	7.3	29.0	19.8	10.8	4.2	5.7	2.9	3.6	3.5	1.6	3.5	5.0
17..........	7.8	21.1	18.1	9.4	4.5	5.8	2.8	3.5	3.5	1.6	2.8	5.2
18..........	7.5	19.7	15.3	8.4	4.7	6.1	2.7	3.4	3.2	1.5	2.5	5.3
19..........	7.5	18.2	13.5	8.2	4.7	6.8	4.1	3.0	2.9	1.5	2.4	4.8
20..........	7.6	16.6	12.3	7.9	4.6	7.3	5.0	3.0	2.7	1.5	2.5	4.5
21..........	7.5	15.5	11.3	7.9	4.5	6.8	4.5	3.4	2.6	1.5	2.3	4.2
22..........	8.2	18.8	10.8	7.6	4.3	6.8	4.0	4.0	2.5	1.5	2.4	4.0
23..........	12.5	24.0	10.7	7.4	4.1	6.5	3.8	4.6	2.4	1.5	3.0	3.8
24..........	15.3	27.7	10.8	7.4	4.0	7.1	3.6	5.5	2.3	1.5	4.6	3.7
25..........	14.0	29.0	10.6	7.5	3.8	7.4	3.5	5.6	2.2	1.5	6.2	4.1
26..........	13.6	26.7	10.4	7.5	3.9	7.6	3.5	7.7	2.2	1.5	6.7	4.9
27..........	11.2	20.6	10.5	7.4	4.0	6.2	3.5	8.2	2.1	1.5	6.3	8.1
28..........	9.7	19.0	14.1	7.2	4.1	4.9	3.6	8.1	2.0	1.5	5.6	10.2
29..........	7.9	......	13.6	6.5	4.1	4.3	3.7	7.0	1.9	1.4	4.7	9.6
30..........	7.9	......	13.0	6.2	4.7	4.1	3.8	6.4	1.9	1.4	4.0	8.4
31..........	8.9	......	13.1	......	5.3	....	5.7	6.1	......	1.4	......	7.8

Daily gage height of Tennessee River at Chattanooga, Tenn, for 1892.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	6.6	6.5	5.7	9.1	8.7	5.6	6.6	4.2	2.1	2.2	1.1	4.1
2..........	6.6	6.2	5.6	8.3	8.2	5.4	5.6	4.1	1.8	2.0	1.2	4.0
3..........	8.1	6.0	5.5	7.4	7.6	5.5	5.5	4.2	1.7	1.9	1.2	3.8
4..........	8.5	5.8	5.3	6.8	7.3	5.8	5.4	4.0	1.5	1.8	1.6	3.7
5..........	8.7	5.5	5.1	6.5	7.4	8.8	6.6	4.1	1.3	1.7	2.0	3.6
6..........	8.4	5.4	5.0	8.5	7.0	9.2	8.9	4.9	2.2	1.6	2.3	3.6
7..........	9.0	5.3	4.9	21.7	6.6	9.3	11.2	4.2	2.1	1.6	2.4	3.3
8..........	9.8	5.8	5.0	31.6	6.3	8.7	11.8	3.8	2.0	1.5	2.4	3.2
9..........	10.0	8.1	6.0	34.2	6.2	8.6	10.1	3.5	2.0	1.5	2.9	3.2
10..........	9.3	11.5	7.1	34.3	5.9	8.3	8.6	3.3	1.9	1.5	4.4	3.0
11..........	8.1	11.3	8.0	31.0	5.5	7.8	9.0	3.3	2.0	1.5	5.9	2.9
12..........	8.3	10.5	7.9	26.6	5.7	8.0	9.5	3.1	1.8	1.5	6.6	2.7
13..........	11.2	8.9	7.6	18.0	5.7	8.1	9.4	3.5	2.1	1.4	7.0	2.6
14..........	22.9	7.7	7.6	12.9	5.5	7.8	8.9	3.6	2.1	1.4	4.4	2.6
15..........	32.9	7.2	6.8	11.7	5.3	6.0	8.7	3.7	2.1	1.4	4.2	3.3
16..........	37.1	7.4	6.2	10.9	5.2	5.3	8.5	3.5	3.1	1.4	4.8	3.4
17..........	37.9	8.0	5.9	10.0	5.1	4.8	8.4	3.1	4.5	1.4	5.6	5.3
18..........	35.2	7.9	6.5	9.4	4.8	4.4	8.1	2.9	4.1	1.3	6.2	8.1
19..........	26.3	7.5	7.5	8.8	5.1	4.4	7.5	2.8	3.5	1.3	6.4	8.7
20..........	18.7	7.7	8.2	12.3	5.5	4.3	7.2	2.8	3.0	1.2	6.2	8.4
21..........	19.0	7.9	8.2	16.2	6.1	7.0	6.9	3.0	2.8	1.2	5.5	9.1
22..........	19.0	8.9	7.8	16.3	6.5	7.8	6.2	2.9	3.0	1.2	4.8	9.8
23..........	17.4	8.9	7.6	15.5	6.9	7.4	5.6	2.9	2.6	1.2	4.4	8.9
24..........	14.9	8.4	8.4	14.8	7.1	7.1	5.4	3.0	2.3	1.2	4.2	7.8
25..........	12.2	7.9	9.6	13.5	7.6	6.9	5.2	2.7	2.3	1.2	3.9	6.7
26..........	10.5	7.5	9.5	13.7	7.8	6.8	5.0	2.8	3.6	1.1	3.4	5.8
27..........	9.7	6.7	10.0	13.6	6.7	6.7	4.6	3.2	3.6	1.1	3.1	5.2
28..........	8.5	6.4	10.6	10.4	6.2	7.3	4.5	3.6	3.1	1.1	3.0	4.8
29..........	7.7	5.9	10.3	9.1	5.8	7.5	4.3	4.4	2.6	1.1	3.0	4.3
30..........	6.9	......	9.7	8.8	5.7	7.2	4.1	3.8	2.4	1.1	3.6	3.9
31..........	6.8	......	9.4	......	5.6	....	3.8	3.3	......	1.1	......	3.3

*List of discharge measurements made on Tennessee River at Chattanooga, Tennessee.**

No.	Date.	Hydrographer.	Meter No	Gage height, feet.	Area of section, (square feet.)	Mean velocity (ft. per sec.)	Discharge (second-feet.)
1	March 15	L. M. Pindell ...	2	10.3	17,971	....	63,039
2	March 16	do ...	2	9.2	16,847	....	58,310
3	April 3	do ...	2	5.1	12,427	....	32,628
4	April 4	do ...	2	5.1	12,427	....	32,643
5	May 5	do ...	2	26.0	36,648	3.93	156,187
6	May 8	do ...	2	26.0	36,825	3.73	151,660
7	May 9	do ...	2	16.0	24,913	3.75	96,979
8	May 17	do ...	2	9.9	17,971	3.39	65,867
9	May 18	do ...	2	10.4	18,539	3.29	67,883

*Meter submerged at one-half depth.

Daily gage height of Tennessee River at Chattanooga, Tenn., for 1893.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1..........	3.4	10.4	8.4	5.5	10.2	7.4	3.9	2.6	8.4	2.6	3.1	2.5
2..........	3.8	12.1	9.1	5.3	9.6	8.0	3.8	2.5	6.8	2.5	3.0	3.9
3..........	4.7	10.6	8.9	5.1	11.0	10.0	4.2	3.1	5.0	2.4	2.8	3.7
4..........	5.7	8.6	8.9	5.1	18.4	8.1	5.2	3.5	6.2	2.4	2.7	4.1
5..........	5.6	8.0	8.7	5.1	24.5	6.6	4.8	3.3	6.0	2.6	2.6	4.3
6..........	5.3	7.7	9.0	5.2	28.2	8.3	3.9	3.2	4.9	2.5	2.5	4.7
7..........	5.2	7.0	9.1	5.4	30.0	16.0	3.8	4.9	4.3	2.9	2.4	4.7
8..........	4.7	6.5	8.8	5.4	28.2	20.7	3.5	5.0	3.5	3.1	2.4	4.5
9..........	4.0	6.1	8.8	5.1	18.0	19.1	3.4	4.1	3.2	2.9	2.3	4.1
10..........	3.8	6.2	9.4	5.1	12.8	15.2	3.6	3.8	2.8	2.9	2.4	4.0
11..........	3.4	8.5	11.1	5.1	11.7	11.8	3.4	3.3	2.8	2.6	2.5	3.7
12..........	2.9	14.7	11.7	5.0	10.4	8.9	3.4	3.0	3.7	2.5	4.8	3.2
13..........	2.9	21.8	11.5	4.8	9.4	7.3	3.3	2.7	5.8	2.4	3.8	3.1
14..........	*	23.6	12.0	10.2	8.8	6.8	3.2	2.5	10.9	2.5	3.6	3.0
15..........	*	22.6	10.6	12.1	8.1	6.5	3.0	2.8	12.7	2.0	3.5	2.9
16..........	*	21.3	9.5	10.4	7.8	6.2	2.8	2.9	9.6	1.7	3.0	3.0
17..........	*	23.6	8.4	8.6	9.4	5.6	2.7	3.8	8.0	9.6	2.8	3.2
18..........	*	29.4	7.6	7.4	10.4	5.4	2.8	5.2	7.0	6.4	2.7	3.5
19..........	*	32.4	7.0	6.5	8.9	5.3	3.0	4.9	6.1	5.7	2.5	3.8
20..........	*	33.4	6.7	6.4	7.7	5.2	3.2	4.0	5.1	5.2	2.6	3.9
21..........	*	32..	6.3	7.2	7.4	5.4	3.5	2.9	4.2	4.1	2.6	3.9
22..........	*	28.5	6.0	7.2	6.7	5.6	3.6	2.6	3.6	3.4	2.6	3.5
23..........	2.9	18.2	5.8	7.1	6.1	5.7	4.6	2.4	3.4	3.1	2.5	3.3
24..........	3.1	12.3	5.7	6.8	5.7	5.4	5.2	2.3	3.2	2.8	2.5	3.1
25..........	3.1	10.4	6.4	6.7	5.4	5.9	5.5	2.2	3.0	3.1	2.4	2.9
26..........	3.4	9.3	6.8	6.0	5.2	5.6	3.7	1.9	2.9	3.3	2.5	2.8
27..........	3.7	8.4	6.8	5.7	5.0	5.2	3.4	1.8	2.7	4.9	2.6	2.7
28..........	3.8	8.2	6.3	7.0	4.6	5.1	2.9	1.6	2.6	4.6	2.8	2.6
29..........	4.4	......	5.9	9.5	5.4	4.7	3.7	1.6	2.4	4.0	2.7	2.5
30..........	5.3	......	5.8	10.4	6.5	4.1	2.6	1.7	2.5	3.5	2.5	2.7
31..........	7.1	......	5.7	......	7.4	....	2.6	1.6	......	3.2	......	3.1

*Frozen at gage.

Daily gage height of Tennessee River at Chattanooga, Tenn., for 1894.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1..........	2.9	5.1	7.7	5.0	3.9	3.8	4.4	2.9	4.0	0.9	1.4	1.0
2..........	3.4	5.0	8.2	4.8	3.8	3.6	4.0	2.9	3.8	.9	1.7	1.0
3..........	3.8	4.9	9.4	5.4	3.7	3.5	3.7	2.9	3.0	1.0	2.3	.9
4..........	3.9	5.5	9.7	5.3	3.7	3.4	4.4	2.8	2.6	1.5	1.6	.9
5..........	3.5	21.9	9.5	6.8	3.6	3.3	4.2	2.9	2.1	1.8	1.4	.9
6..........	3.1	25.5	9.3	6.9	3.5	3.2	3.7	3.0	2.0	1.8	1.5	.9
7..........	4.9	23.9	8.5	7.2	3.4	2.9	3.2	2.9	1.8	1.5	1.5	.9
8..........	6.1	19.7	8.2	7.4	3.3	2.8	3.3	2.9	1.7	1.3	1.3	.9
9..........	9.3	16.1	7.9	6.6	3.4	2.6	3.1	3.0	1.5	1.1	1.2	1.1
10..........	9.0	16.0	7.2	5.7	3.3	2.5	3.3	2.6	1.4	1.0	1.1	1.2
11..........	8.5	16.7	6.9	5.9	3.2	2.5	3.7	2.3	1.4	.8	1.0	1.6
12..........	7.9	15.4	6.6	7.2	4.7	2.4	3.3	2.1	1.4	.9	1.0	3.8
13..........	8.3	15.2	6.7	8.5	5.1	2.3	2.7	1.9	1.3	1.2	.9	8.6
14..........	8.0	14.1	7.2	7.8	4.8	2.3	2.4	1.8	1.2	1.9	.8	11.1
15..........	7.8	12.2	7.0	7.2	4.3	2.2	2.1	2.0	1.5	2.4	.8	11.2
16..........	7.8	10.3	6.9	6.9	4.0	2.1	1.9	3.6	1.8	2.1	.8	10.8
17..........	7.1	9.5	6.8	6.3	4.1	2.0	1.8	4.6	1.8	1.7	.8	8.6
18..........	7.2	8.6	7.3	5.5	5.2	2.1	2.8	3.5	2.0	1.4	.7	6.6
19..........	6.3	8.4	7.4	5.0	5.0	2.4	2.4	3.0	2.0	1.1	.8	4.7
20..........	6.0	8.3	7.7	5.1	5.4	2.5	2.4	3.1	1.6	1.0	.9	4.2
21..........	5.3	8.5	7.1	4.9	5.6	[illegible]	3.3	3.6	1.5	.9	.9	3.6
22..........	5.0	8.7	8.8	4.8	6.2	2.5	3.7	3.7	1.5	.8	.9	3.2
23..........	5.0	8.8	8.7	4.7	6.8	2.3	3.8	4.0	1.8	.8	1.0	2.8
24..........	5.2	8.2	8.1	4.6	6.9	2.2	3.4	3.6	1.8	.8	1.0	2.7
25..........	5.3	7.9	7.7	4.5	7.1	2.2	4.0	3.0	1.6	.8	1.1	2.5
26..........	5.2	7.0	7.3	4.3	6.7	2.5	1.4	2.6	1.3	.8	1.2	2.4
27..........	5.4	7.7	7.0	4.2	6.0	2.6	3.9	2.2	1.1	.7	1.2	4.2
28..........	5.4	7.7	6.5	4.1	5.6	2.7	3.8	2.7	1.0	.7	1.1	6.9
29..........	5.1	......	5.9	4.0	5.1	2.9	3.6	2.4	.9	.7	1.1	8.4
30..........	5.0	......	5.7	4.0	4.7	4.3	3.3	2.7	.8	1.0	1.1	7.9
31..........	4.9	......	5.2	......	4.2	....	3.3	4.3	......	1.1	......	5.8

Daily gage height of Tennessee River at Chattanooga, Tenn., for 1895.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.7	7.6	6.8	7.8	6.0	5.6	3.[illegible]	4.4	3.3	0.9	1.1	1.4
2	3.9	7.2	7.3	7.4	5.8	5.2	3.4	4.1	3.4	.8	1.2	1.5
3	3.3	7.3	12.1	6.8	5.5	4.8	3.8	3.8	3.2	.8	1.3	1.4
4	3.2	7.5	18.2	6.5	5.4	4.5	4.0	3.5	3.1	.8	1.6	1.4
5	3.1	7.6	19.9	6.3	5.7	4.2	4.5	3.4	2.9	.8	1.6	1.4
6	3.1	7.4	18.2	6.2	6.0	4.4	5.0	3.0	2.8	.8	1.3	1.6
7	3.3	6.9	13.4	6.0	6.5	4.6	5.0	3.2	2.8	.8	1.3	1.5
8	4.0	6.5	10.5	9.6	7.0	5.2	5.1	3.3	2.8	.9	1.2	1.4
9	10.9	6.4	9.2	10.7	8.2	5.1	5.5	3.3	2.5	.8	1.1	1.3
10	20.5	5.0	8.6	11.4	8.6	4.6	5.7	3.0	2.4	.9	1.2	1.3
11	28.5	4.0	8.1	13.0	9.0	4.2	5.1	3.0	2.3	1.0	1.3	1.4
12	32.1	3.3	7.5	12.5	8.8	3.8	4.4	2.9	2.4	1.0	1.7	1.5
13	31.2	4.2	7.8	10.4	8.9	3.6	3.8	3.2	2.5	1.0	2.1	1.8
14	28.3	*	8.0	8.8	9.5	3.5	3.4	2.9	2.4	1.0	2.4	1.9
15	19.5	4.3	8.7	7.9	9.0	3.4	3.2	2.8	2.3	.9	2.2	2.0
16	12.3	4.7	9.4	7.4	8.2	3.4	3.2	2.7	2.2	1.0	2.0	1.9
17	10.9	4.7	9.2	7.0	7.7	3.8	3.7	3.1	2.1	1.0	1.9	1.8
18	10.0	4.2	9.6	9.0	7.1	3.7	3.6	4.3	2.3	1.0	1.8	1.7
19	9.7	4.7	9.4	11.8	7.0	3.5	3.3	4.9	2.2	.9	1.7	1.6
20	9.1	4.6	8.9	11.8	7.2	3.2	3.0	5.7	2.0	.9	1.5	1.5
21	9.6	5.1	14.3	9.9	7.1	3.1	2.7	5.3	2.1	.8	1.3	1.6
22	10.2	5.6	20.6	8.6	6.7	3.2	2.7	6.1	1.9	.8	1.1	2.1
23	9.9	6.1	22.7	7.7	6.5	3.1	2.5	5.3	1.6	.7	1.3	3.3
24	9.1	6.7	22.0	7.1	5.8	3.0	2.4	4.8	1.4	.7	1.4	4.2
25	10.8	6.8	18.2	6.7	5.6	2.9	2.4	4.6	1.3	.7	1.3	4.6
26	10.8	6.5	13.0	6.3	5.6	2.9	2.9	4.7	1.3	.7	1.3	4.3
27	10.0	6.3	11.3	6.0	7.0	2.6	3.8	4.2	1.2	.7	1.3	4.2
28	9.3	6.3	10.6	6.0	7.5	2.5	10.2	3.7	1.1	.7	1.3	4.5
29	8.8	......	9.5	5.9	7.4	2.5	10.4	3.5	1.0	.7	1.3	5.2
30	8.6	......	8.9	5.9	6.7	2.6	7.4	3.7	0.9	.7	1.5	4.7
31	8.4	......	8.4	......	6.0	....	5.3	3.4	......	1.0	......	4.7

*Frozen.

Rating table for Tennessee River at Chattanooga, Tennessee.

[This table is applicable from Jan. 1, 1890, to Dec. 31, 1895.]

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
0.7	16,360	11.0	66,850	22.5	133,665	34.0	293,820
0.8	16,560	11.5	69,755	23.0	136,570	34.5	302,720
0.9	16,780	12.0	72,660	23.5	139,475	35.0	311,620
1.0	17,000	12.5	75,565	24.0	142,380	35.5	320,520
1.5	18,160	13.0	78,470	24.5	145,285	36.0	329,420
2.0	19,500	13.5	81,375	25.0	148,190	36.5	338,320
2.5	21,100	14.0	84,280	25.5	151,095	37.0	347,220
3.0	23,000	14.5	87,185	26.0	154,000	37.5	356,120
3.5	25,090	15.0	90,090	26.5	162,500	38.0	365,020
4.0	27,300	15.5	92,995	27.0	171,000	38.5	373,920
4.5	29,660	16.0	95,900	27.5	179,900	39.0	382,820
5.0	32,200	16.5	98,805	28.0	188,800	39.5	391,720
5.5	34,895	17.0	101,710	28.5	197,700	40.0	400,620
6.0	37,800	17.5	104,615	29.0	206,600	40.5	409,520
6.5	40,705	18.0	107,520	29.5	215,500	41.0	418,420
7.0	43,610	18.5	110,425	30.0	224,400	41.5	427,320
7.5	46,515	19.0	113,330	30.5	233,300	42.0	436,220
8.0	49,420	19.5	116,235	31.0	242,200	42.5	445,120
8.5	52,325	20.0	119,140	31.5	251,100	43.0	454,020
9.0	55,230	20.5	122,045	32.0	260,000	43.5	462,920
9.5	58,135	21.0	124,950	32.5	268,900	44.0	471,820
10.0	61,040	21.5	127,855	33.0	276,020	44.5	480,720
10.5	63,945	22.0	130,760	33.5	284,920		

NOTE—This table applied to the foregoing "daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Daily gage height of Tennessee River at Chattanooga, Tenn., for 1896.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.9	4.4	4.1	14.8	3.4	2.6	3.3	5.5	2.4	2.5	1.2	2.4
2	5.0	6.2	3.9	27.7	3.4	3.0	3.2	5.2	2.1	2.3	1.2	2.5
3	4.9	10.0	3.8	34.4	3.4	4.4	3.1	4.8	1.9	2.6	1.3	2.5
4	4.9	11.6	3.7	38.8	3.5	5.7	3.2	4.6	1.8	3.0	1.5	2.6
5	4.7	10.5	3.6	40.5	4.0	5.2	3.3	4.5	1.6	2.7	1.5	2.6
6	4.3	9.3	3.5	36.9	4.6	4.7	3.2	4.9	1.6	2.6	1.6	2.7
7	3.6	11.8	3.4	23.3	4.6	4.1	3.6	5.0	1.5	2.1	2.3	2.9
8	3.3	14.0	3.5	11.6	4.3	3.5	5.0	4.2	2.0	1.7	3.5	3.0
9	3.2	13.8	3.5	9.0	4.0	3.5	3.9	3.8	2.8	1.5	4.2	2.8
10	3.2	13.2	3.4	8.0	3.7	4.5	14.2	3.4	2.7	1.4	4.1	2.8
11	3.1	12.8	3.6	7.2	3.4	7.0	21.1	3.3	2.4	1.2	3.3	2.7
12	3.1	11.4	3.6	6.7	3.1	6.3	21.6	3.4	2.0	1.2	3.2	2.6
13	2.9	10.1	3.8	6.2	2.9	5.1	15.6	3.2	1.8	1.2	5.8	2.4
14	2.7	11.1	3.8	5.8	2.8	4.3	11.5	3.2	1.6	1.2	7.3	2.6
15	2.6	12.8	3.7	5.5	2.7	3.6	11.2	3.1	1.6	1.5	6.5	4.1
16	2.4	13.6	3.8	5.2	2.6	8.2	11.4	3.0	1.5	1.7	5.5	6.5
17	2.3	12.5	5.5	5.0	2.5	8.0	11.0	3.0	1.3	1.6	4.9	6.6
18	2.3	11.0	10.1	4.8	2.4	2.8	13.9	2.9	1.4	1.6	4.3	6.3
19	2.3	9.0	13.1	4.2	2.4	2.9	12.5	2.7	1.4	1.7	3.8	6.4
20	2.3	7.6	15.7	4.4	2.2	3.1	9.6	2.6	1.3	1.6	3.4	6.8
21	2.3	6.7	13.8	4.2	2.1	3.7	7.6	2.4	1.2	1.6	3.0	7.0
22	2.5	6.0	11.2	4.1	2.1	3.5	6.5	2.4	1.2	1.4	2.8	7.2
23	3.1	5.4	9.5	4.1	2.5	3.5	8.5	2.2	1.3	1.2	2.5	7.3
24	5.0	4.9	8.4	4.0	3.2	3.3	8.8	2.2	1.4	1.2	2.4	7.0
25	6.5	4.7	7.9	4.0	3.6	3.1	8.6	2.8	1.6	1.2	2.3	6.6
26	8.2	4.6	7.5	3.8	3.8	2.9	7.8	2.6	2.0	1.2	2.2	5.9
27	8.0	4.5	7.2	3.8	3.2	2.6	11.1	2.7	1.7	1.2	2.1	5.3
28	7.0	4.4	6.7	3.8	3.1	2.6	12.2	3.2	1.5	1.2	2.2	4.8
29	6.0	4.2	6.2	3.6	2.8	2.8	9.3	4.0	1.5	1.1	5.3	4.4
30	5.3	......	5.8	3.6	2.7	3.0	7.2	3.6	2.7	1.1	9.4	3.7
31	4.8	......	7.7	......	2.5	....	6.2	2.8	......	1.3	......	3.0

The following discharge measurements were made by Max Hall and others during 1897:

May 8—Gage height, 7.07 feet; discharge, 44,187 second-feet.
May 28—Gage neight, 4.52 feet; discharge, 25,892 second-feet.
June 29—Gage height, 5.76 feet; discharge, 32,943 second-feet.
July 13—Gage height, 4.59 feet; discharge, 26,884 second-feet.
Sept. 7—Gage height, 1.67 feet; discharge, 10,313 second-feet.
Oct. 6—Gage height, 0.48 feet; discharge, 5,969 second-feet.
Nov. 16—Gage height, 0.83 feet; discharge, 5,552 second-feet.
Dec. 28—Gage height, 10.30 feet; discharge, 67,000 second-feet.

Daily gage height of Tennessee River at Chattanooga, Tenn., for 1897.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	2.4	3.0	12.5	8.7	5.9	4.3	5.0	4.4	2.1	0.8	0.8	1.0
2	2.5	7.0	9.6	12.2	6.3	4.2	4.[illegible]	3.9	2.2	.8	.9	1.2
3	2.8	10.1	8.6	15.0	7.4	4.1	3.8	3.8	1.9	.7	1.0	1.3
4	2.6	10.5	9.0	16.0	9.6	4.1	3.4	3.6	1.8	.6	1.2	2.0
5	2.6	9.4	9.5	26.0	9.6	4.1	3.4	3.3	1.8	.5	1.2	3.3
6	2.7	8.3	12.1	30.4	8.5	4.1	4.0	3.5	1.7	.5	1.3	3.8
7	2.9	8.8	19.2	29.7	7.7	4.4	3.8	4.4	1.7	.5	1.4	3.9
8	3.0	10.7	25.1	25.4	7.2	4.4	3.8	4.2	1.6	.4	1.2	3.5
9	2.8	14.1	24.2	20.0	6.6	4.0	4.4	4.2	1.6	.4	1.2	2.9
10	2.8	15.5	21.3	16.0	6.2	5.2	4.0	5.6	1.4	.4	1.2	2.6
11	2.7	13.2	22.3	14.0	6.0	5.0	4.1	5.2	1.3	.5	1.1	2.4
12	2.6	10.8	28.4	26.0	6.2	•5.7	4.5	4.6	1.2	.6	1.0	2.1
13	2.4	9.9	34.9	11.4	7.8	5.0	4.6	4.1	1.2	.9	1.0	1.8
14	2.6	10.0	37.9	10.3	18.4	4.3	4.2	3.5	1.1	1.4	.9	1.8
15	4.1	10.5	37.9	9.7	22.4	3.9	3.8	3.1	1.0	1.1	.8	2.5
16	6.5	10.7	37.0	9.8	20.3	3.6	3.6	2.8	1.0	1.2	.8	2.7
17	6.6	9.8	36.0	10.2	16.5	3 7	4.5	2.[illegible]	.9	1.2	.8	2.5
18	6.3	8.6	33.8	9.9	11.9	3.6	6.3	3.0	.9	1.2	.8	2.5
19	.64	7.6	29.6	9.3	9.1	3.3	6.1	3.4	.8	1.1	.8	2.6
20	6.8	7.0	29.6	8.8	7.7	3.[illegible]	5.6	3.0	.8	1.4	.7	3.4
21	7.0	7.0	32.4	8.1	6.9	4.1	6.7	3.0	.9	2.0	.7	4.5
22	7.2	8.3	33.3	7.5	6.4	5.0	6.1	3.4	.9	1.9	.7	7.1
23	7.3	13.2	30.9	7.0	5.9	4.8	5.8	3.1	.8	1.6	.7	10.2
24	7.0	25.2	25.0	6.7	5.6	5.3	6.0	3.8	.9	1.4	.7	9.3
25	6.6	31.6	18.1	6.4	5.3	5.5	8.4	3.4	.8	1.6	.7	7.7
26	5.9	34.8	14.2	6.2	5.1	6.2	9.7	2.9	.8	1.4	.7	6.4
27	5.3	33.8	12.2	6.0	4.8	5.4	13.5	2.8	.7	1.2	.7	5.6
28	4.8	23.6	10.8	6.1	4.6	5.5	8.7	2.8	.7	1.0	.7	5.0
29	4.4	......	9.8	6.2	4.4	6.2	6.7	2.5	.7	.9	.7	4.5
30	3.7	......	9.1	5.8	4.2	5.2	5.6	2.2	.8	.8	.9	4.0
31	3.0	......	8.6	......	4 2	....	5.0	2.1	......	.8	......	3.8

Rating table for Tennessee River at Chattanooga, Tennessee, for (a) 1896-1897.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
0.2	3,080	1.4	10,208	3.4	22,088	12.0	73,172
0.3	3,674	1.6	11,396	3.6	23,276	13.0	79,112
0.4	4,268	1.8	12,584	3.8	24,464	14.0	85,052
0.5	4,862	2.0	13,772	4.0	25,652	15.0	90,992
0.6	5,456	2.2	14,960	4.4	28,028	16.0	96,932
0.7	6,050	2.4	16,148	4.8	30,404	18.0	108,812
0.8	6,644	2.6	17,336	6.0	37,532	20.0	120,690
0.9	7,238	2.8	18,524	8.0	49,412	22.0	132,570
1.0	7,832	3.0	19,712	10.0	61,292	24.0	144,450
1.2	9,020	3.2	20,900	11.0	67,232	26.0	156,330

a Above 26 feet use table as published in the Eighteenth Ann. Rept., Part IV, p. 120.

NOTE—This table applied to the foregoing "daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made on the Tennessee River at Chattanooga, Tenn., by Max Hall and others during 1898:

May 10—Gage height, 4.14 feet; discharge, 22,066 second-feet.
July 29—Gage height, 5.30 feet; discharge, 29,693 second-feet.
August 19—Gage height, 6.37 feet; discharge, 36,671 second-feet.
Oct. 6—Gage height, 17.60 feet; discharge, 120,359 second-feet.
Oct. 28—Gage height, 6.00 feet; discharge, 35,953 second-feet.
Nov. 29—Gage height, 4.75 feet; discharge, 29,569 second-feet.
Nov. 29—Gage height, 4.70 feet; discharge, 31,340 second-feet.

Daily gage height, in feet, of Tennessee River at Chattanooga, Tenn., for 1898.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	3.45	7.55	3.30	17.45	6.40	3.35	2.45	8.15	3.55	3.55	4.60	5.10
2..........	3.25	6.70	3.15	17.80	5.80	3.30	2.35	7.55	3.95	3.30	4.30	5.05
3..........	3.05	6.15	3.00	15.00	5.40	3.30	2.25	6.45	9.15	3.20	4.25	4.90
4..........	2.90	5.40	2.95	11.45	5.05	3.30	2.05	5.35	18.50	3.90	4.05	5.00
5..........	2.75	5.00	3.30	10.35	4.70	2.85	2.35	6.25	25.00	8.90	3.90	5.05
6..........	2.65	4.55	3.45	12.15	4.45	2.55	2.10	11.85	22.15	16.90	3.90	5.60
7..........	2.70	4.45	3.50	11.60	4.35	2.35	2.10	14.65	15.70	16.50	4.25	5.95
8..........	2.80	4.35	3.40	10.30	4.10	2.20	2.15	12.55	11.25	10.75	4.45	5.90
9..........	3.05	4.30	3.25	9.30	4.20	2.05	2.60	10.15	9.50	8.80	4.50	5.85
10..........	3.25	4.15	3.05	8.30	4.15	1.95	3.05	8.50	8.60	8.40	4.45	5.55
11..........	3.25	4.00	2.90	8.60	4.45	1.80	3.50	9.05	7.45	7.55	4.65	5.10
12..........	5.50	3.90	2.85	9.50	4.65	1.95	3.40	12.30	6.45	6.55	5.05	4.75
13..........	13.20	3.80	2.80	9.40	4.40	1.80	3.20	14.85	5.70	6.00	5.30	4.55
14..........	14.40	3.80	2.85	9.00	4.15	1.75	2.80	15.85	5.20	5.70	4.95	4.30
15..........	12.25	3.80	3.15	9.05	3.95	1.65	2.85	14.95	4.80	5.35	4.55	4.00
16..........	12.20	3.70	5.10	9.15	3.90	1.75	3.50	11.60	4.45	4.90	4.40	3.85
17..........	12.35	3.55	5.05	8.60	3.80	2.00	4.55	8.90	4.25	4.70	4.55	3.70
18..........	10.00	3.50	5.20	8.20	3.70	2.35	5.35	7.10	3.95	5.25	4.75	3.60
19..........	9.20	3.30	5.50	8.00	3.70	3.50	4.60	6.40	3.75	6.70	4.95	3.75
20..........	11.70	3.30	6.10	7.95	3.65	4.05	4.15	6.05	3.55	7.75	5.30	5.20
21..........	13.80	3.20	5.70	7.40	3.60	5.85	4.00	5.95	3.45	9.30	5.85	5.85
22..........	13.40	3.25	5.45	7.05	3.60	5.55	3.30	5.65	3.55	8.80	6.05	6.00
23..........	12.55	3.40	5.15	6.60	3.50	5.05	3.30	5.40	5.00	7.65	6.55	5.85
24..........	12.35	3.50	4.65	6.85	3.40	4.55	3.40	4.75	5.05	7.25	6.85	5.35
25..........	12.35	3.60	4.30	6.65	3.45	3.70	3.55	4.30	6.40	7.20	6.55	5.20
26..........	16.05	3.80	4.15	6.30	3.70	3.40	3.55	4.05	7.20	7.60	6.10	5.40
27..........	18.20	3.50	4.45	6.45	4.95	2.90	4.55	4.00	6.15	6.90	5.65	5.90
28..........	16.70	3.35	4.45	7.10	5.60	2.80	5.55	4.10	5.00	6.20	5.15	5.70
29..........	14.15	......	4.65	7.05	4.90	2.90	5.35	[illegible]	4.30	5.65	4.80	5.15
30..........	11.20	......	5.55	6.75	4.20	2.55	5.90	4.10	3.85	5.15	4.95	4.80
31..........	8.95	......	13.25	......	3.70	....	7.90	3.85	......	4.85	......	4.50

Rating table for Tennessee River at Chattanooga, Tenn., for 1898.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second feet.*	*Feet.*	*Second feet.*	*Feet.*	*Second feet.*
0.5	5,900	3.7	19,550	6.9	42,370	10.5	68,650
0.6	6,266	3.8	20,120	7.0	43,100	11.0	72,300
0.7	6,634	3.9	20,700	7.1	43,830	11.5	75,950
0.8	7,004	4.0	21,320	7.2	44,560	12.0	79,600
0.9	7,376	4.1	21,950	7.3	45,290	12.5	83,250
1.0	7,750	4.2	22,580	7.4	46,020	13.0	86,900
1.1	8,126	4.3	23,350	7.5	46,750	13.5	90,550
1.2	8,504	4.4	24,120	7.6	47,480	14.0	94,200
1.3	8,884	4.5	24,850	7.7	48,210	14.5	97,850
1.4	9,266	4.6	25,580	7.8	48,940	15.0	101,500
1.5	9,650	4.7	26,310	7.9	49,670	15.5	105,150
1.6	10,046	4.8	27,040	8.0	50,400	16.0	108,800
1.7	10,444	4.9	27,770	8.1	51,130	16.5	112,450
1.8	10,844	5.0	28,500	8.2	51,860	17.0	116,100
1.9	11,246	5.1	29,230	8.3	52,590	17.5	119,750
2.0	11,650	5.2	29,960	8.4	53,320	18.0	123,400
2.1	12,056	5.3	30,690	8.5	54,050	18.5	127,050
2.2	12,464	5.4	31,420	8.6	54,780	19.0	130,700
2.3	12,874	5.5	32,150	8.7	55,510	19.5	134,350
2.4	13,286	5.6	32,880	8.8	56,240	20.0	138,000
2.5	13,700	5.7	33,610	8.9	56,970	20.5	141,650
2.6	14,126	5.8	34,340	9.0	57,700	21.0	145,300
2.7	14,562	5.9	35,070	9.1	58,430	21.5	148,950
2.8	15,008	6.0	35,800	9.2	59,160	22.0	152,600
2.9	15,464	6.1	36,530	9.3	59,890	22.5	156,250
3.0	15,930	6.2	37,260	9.4	60,620	23.0	159,900
3.1	16,410	6.3	37,990	9.5	61,350	23.5	163,550
3.2	16,900	6.4	38,720	9.6	62,080	24.0	167,200
3.3	17,400	6.5	39,450	9.7	62,810	24.6	171,680
3.4	17,920	6.6	40,180	9.8	63,540		
3.5	18,460	6.7	40,910	9.9	64,270		
3.6	19,000	6.8	41,640	10.0	65,000		

NOTE—This table applied to the foregoing "daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following measurements were made by Max Hall and others during 1899:

May 3—Gage height, 6.71 feet; discharge, 37,770 second-feet.
May 26—Gage height, 4.76 feet; discharge, 25,526 second-feet.
June 21—Gage height, 4.15 feet; discharge, 21,391 second-feet.
Sept. 15—Gage height, 1.90 feet; discharge, 10,819 second-feet.
Oct. 27—Gage height, 0.80 foot; discharge, 6,566 second-feet.

Daily gage height in feet of Tennessee River at Chattanooga, Tenn., for 1899.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	4.75	5.70	19.25	22.80	7.60	4.15	3.45	4.20	2.20	1.20	1.10	1.70
2	4.95	5.65	17.60	19.50	7.10	4.25	3.30	3.55	2.35	1.10	1.10	1.70
3	5.30	5.60	15.15	14.90	6.70	4.40	3.05	3.05	2.80	1.05	1.05	1.70
4	5.80	10.70	14.15	12.95	6.30	4.85	2.80	2.75	3.05	.95	1.10	1.70
5	5.95	23.10	17.95	13.25	6.15	4.65	2.60	2.45	2.65	.90	1.50	1.80
6	7.25	30.45	24.50	14.70	7.10	4.25	2.60	2.45	3.25	.80	1.50	1.70
7	18.80	34.30	26.55	15.70	8.50	4.05	2.65	2.40	1.95	.85	1.50	1.60
8	18.40	36.95	27.60	18.05	9.35	3.75	3.05	2.40	1.80	1.00	1.45	1.50
9	17.35	38.25	27.70	17.75	10.00	3.55	2.90	2.25	1.60	1.15	1.35	1.40
10	17.15	36.75	16.15	15.70	10.70	3.40	2.60	2.10	1.80	1.60	1.20	1.40
11	13.85	30.30	11.85	14.20	11.15	3.90	2.55	2.10	1.70	1.80	1.15	1.60
12	10.50	19.35	10.60	12.90	10.40	4.30	2.45	2.00	2.00	1.85	1.10	5.20
13	9.15	12.15	9.55	11.65	9.60	5.25	2.30	2.00	1.80	1.70	1.00	6.45
14	8.10	9.50	11.20	10.70	9.30	5.80	2.20	2.25	2.00	1.65	1.00	7.40
15	7.55	8.50	24.55	10.00	9.55	6.45	2.15	2.65	1.85	1.40	1.00	7.15
16	7.30	7.55	34.25	9.40	9.20	6.10	1.95	2.65	1.65	1.25	1.00	6.20
17	7.40	7.95	36.90	8.75	8.70	6.40	1.90	2.40	1.45	1.15	1.00	5.20
18	7.45	9.55	36.15	8.40	7.75	6.20	1.80	2.30	1.35	1.15	1.00	4.25
19	7.25	11.30	35.85	8.00	6.90	5.25	1.90	2.15	1.20	1.10	1.00	3.85
20	7.00	12.65	37.05	7.55	6.40	4.70	2.05	1.90	1.05	1.10	.95	4.25
21	6.80	11.50	39.20	7.35	5.90	4.20	2.05	1.70	1.00	1.10	.85	4.40
22	6.45	10.65	40.00	7.05	5.60	3.75	2.40	1.60	1.05	1.10	.85	4.40
23	5.90	10.10	38.70	7.85	5.35	3.50	2.70	1.45	1.30	1.05	1.00	4.15
24	5.65	9.75	32.70	9.65	5.30	3.25	3.50	1.30	1.50	1.00	1.15	5.65
25	6.05	9.50	23.15	9.35	5.05	3.15	3.40	1.20	1.50	.95	1.20	6.15
26	6.35	9.20	16.30	10.75	4.80	3.00	3.00	1.20	1.45	.85	1.70	6.30
27	5.85	13.20	13.65	10.30	4.65	3.25	3.05	1.20	1.30	.80	1.80	5.85
28	5.75	18.45	13.95	9.20	4.40	3.65	3.65	1.25	1.20	.80	1.85	5.55
29	5.55	......	17.30	8.35	4.30	3.50	4.25	1.50	1.25	.90	1.80	5.10
30	5.30	......	21.20	7.75	4.20	3.30	4.25	1.85	1.30	1.00	1.75	4.65
31	5.80	......	22.80	......	4.25	....	5.15	1.75	......	1.05	......	3.85

During 1900 the following measurements were made by Max Hall and others:

March 13—Gage height, 11.25 feet; discharge, 66,012 secod-feet.
July 27—Gage height, 3.45 feet; discharge, 18,470 second-feet.

Daily gage height in feet of Tennessee River at Chattanooga, Tenn., for 1900.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1	3.05	3.25	8.05	7.85	6.20	2.85	8.85	6.20	2.10	2.00	2.90	8.70
2	*	2.95	8.70	7.20	5.65	2.80	8.15	5.40	2.00	1.80	2.60	6.50
3	*	2.60	10.90	6.85	5.35	3.00	6.95	4.70	2.30	1.70	2.50	5.60
4	*	2.50	12.50	7.25	5.15	3.20	6.30	4.20	2.50	1.50	2.90	5.10
5	*	2.90	12.75	8.05	4.95	3.20	5.80	3.60	2.30	1.40	3.30	5.60
6	2.10	3.50	10.65	8.55	4.80	3.50	5.40	3.20	2.00	1.30	3.70	6.90
7	2.20	3.95	10.00	7.85	4.65	5.65	5.00	2.90	1.70	1.30	4.20	8.30
8	2.30	3.90	11.65	7.05	4.45	6.65	4.50	2.60	1.60	1.60	4.20	9.20
9	2.35	5.35	14.55	6.50	4.45	6.15	4.2[illegible]	2.4[illegible]	1.40	1.80	3.70	8.50
10	2.45	8.40	16.50	6.10	4.35	5.30	4.20	2.30	1.30	2.10	3.20	7.00
11	3.35	9.40	16.15	6.50	4.30	5.00	4.30	2.10	1.20	2.10	3.00	6.10
12	6.05	8.95	14.25	7.50	4.30	4.90	3.80	2.00	1.10	2.50	2.70	5.40
13	8.15	13.90	11.65	7.40	4.15	4.50	3.40	1.90	1.00	3.00	2.50	4.90
14	8.70	21.55	9.85	7.00	4.00	5.20	3.30	1.90	1.10	2.50	2.30	4.50
15	8.45	24.00	8.65	6.50	3.85	5.30	3.30	2.10	1.80	1.90	2.20	4.30
16	7.80	21.40	8.00	6.30	3.75	5.25	3.30	2.20	3.10	1.80	2.10	4.20
17	6.35	17.00	7.80	8.75	3.60	5.45	3.20	2.30	4.00	1.60	2.00	4.00
18	5.50	12.05	7.55	10.65	3.50	6.15	3.10	2.30	4.10	1.50	2.00	3.60
19	5.80	9.25	7.55	9.75	3.40	8.85	3.00	2.30	4.60	1.40	1.90	3.40
20	8.50	7.70	8.55	9.40	3.40	9.20	2.90	2.20	4.70	1.30	1.90	3.30
21	9.40	7.10	11.60	11.70	3.25	8.90	2.70	1.90	3.90	1.20	2.10	3.30
22	8.85	7.70	14.95	12.00	3.15	7.65	2.50	1.80	3.00	1.20	2.20	4.00
23	7.95	8.50	17.40	11.35	3.05	6.40	2.50	1.70	2.60	1.40	2.30	4.20
24	7.20	8.55	16.45	10.70	3.00	6.25	2.80	1.80	2.40	2.20	2.80	4.70
25	6.15	8.55	12.65	9.75	3.15	7.15	3.00	1.90	2.70	4.10	3.20	5.20
26	5.50	9.50	11.15	8.50	3.20	7.60	3.10	2.50	2.70	7.00	7.80	5.40
27	5.00	9.30	10.90	7.80	3.35	8.05	3.30	3.10	2.60	7.50	13.90	5.20
28	4.65	8.45	10.70	7.45	3.60	8.20	4.60	2.70	2.40	6.00	15.60	4.60
29	4.20	......	10.20	7.05	3.60	8.60	8.00	2.50	2.30	4.90	15.60	4.30
30	3.90	......	9.35	6.60	3.35	8.70	8.20	2.30	2.20	3.70	13.20	4.[illegible]
31	3.55	......	8.50	......	3.05	....	7.30	2.20	......	3.40	......	4.50

*Frozen at gage.

Rating table for Tennessee River at Chattanooga, Tennessee, for 1899-1900.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
0.8	6,600	10.7	62,340	20.6	123,720	30.5	185,100
0.9	6,950	10.8	62,960	20.7	124,340	30.6	185,720
1.0	7,300	10.9	63,580	20.8	124,960	30.7	186,340
1.1	7,670	11.0	64,200	20.9	125,580	30.8	186,960
1.2	8,040	11.1	64,820	21.0	126,200	30.9	187,580
1.3	8,430	11.2	65,440	21.1	126,820	31.0	188,200
1.4	8,820	11.3	66,060	21.2	127,440	31.1	188,820
1.5	9,220	11.4	66,680	21.3	128,060	31.2	189,440
1.6	9,620	11.5	67,300	21.4	128,680	31.3	190,060
1.7	10,020	11.6	67,920	21.5	129,300	31.4	190,680
1.8	10,430	11.7	68,540	21.6	129,920	31.5	191,300
1.9	10,840	11.8	69,160	21.7	130,540	31.6	191,920
2.0	11,250	11.9	69,780	21.8	131,160	31.7	192,540
2.1	11,660	12.0	70,400	21.9	131,780	31.8	193,160
2.2	12,080	12.1	71,020	22.0	132,400	21.9	193,780
2.3	12,500	12.2	71,640	22.1	133,020	32.0	194,400
2.4	12,930	12.3	72,260	22.2	133,640	32.1	195,020
2.5	13,360	12.4	72,880	22.3	134,260	32.2	195,640
2.6	13,800	12.5	73,500	22.4	134,880	32.3	196,260
2.7	14,240	12.6	74,120	22.5	135,500	32.4	196,880
2.8	14,680	12.7	74,740	22.6	136,120	32.5	197,500
2.9	15,140	12.8	75,360	22.7	136,740	32.6	198,120
3.0	15,600	12.9	75,980	22.8	137,360	32.7	198,740
3.1	16,080	13.0	76,600	22.9	137,980	32.8	199,360
3.2	16,550	13.1	77,220	23.0	138,600	32.9	199,980
3.3	17,050	13.2	77,840	23.1	139,220	33.0	200,600
3.4	17,550	13.3	78,460	23.2	139,840	33.1	201,220
3.5	18,050	13.4	79,080	23.3	140,460	33.2	201,840
3.6	18,550	13.5	79,700	23.4	141,080	33.3	202,460
3.7	19,050	13.6	80,320	23.5	141,700	33.4	203,080
3.8	19,600	13.7	80,940	23.6	142,320	33.5	203,700
3.9	20,200	13.8	81,560	23.7	142,940	33.6	204,320
4.0	20,800	13.9	82,180	23.8	143,560	33.7	204,940
4.1	21,420	14.0	82,800	23.9	144,180	33.8	205,560
4.2	22,040	14.1	83,420	24.0	144,800	33.9	206,180
4.3	22,660	14.2	84,040	24.1	145,420	34.0	206,800
4.4	23,280	14.3	84,660	24.2	146,040	34.1	207,420
4.5	23,900	14.4	85,280	24.3	146,660	34.2	208,040
4.6	24,520	14.5	85,900	24.4	147,280	34.3	208,660
4.7	25,140	14.6	86,520	24.5	147,900	34.4	209,280
4.8	25,760	14.7	87,140	24.6	148,520	34.5	209,900
4.9	26,380	14.8	87,760	24.7	149,140	34.6	210,520
5.0	27.000	14.9	88,380	24.8	149,760	34.7	211,140
5.1	27,620	15.0	89,000	24.9	150,380	34.8	211,760
5.2	28,240	15.1	89,620	25.0	151,000	34.9	212,380
5.3	28,860	15.2	90,240	25.1	151,620	35.0	213,000
5.4	29,480	15.3	90,860	25.2	152,240	35.1	213,620
5.5	30,100	15.4	91,480	25.3	152,860	35.2	214,240
5.6	30,720	15.5	92,100	25.4	153,480	35.3	214,860

Rating table for Tennessee River at Chattanooga, Tennessee, for 1899-1900.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
5.7	31,340	15.6	92,720	25.5	154,100	35.4	215,480
5.8	31,960	15.7	93,340	25.6	154,720	35.5	216,100
5.9	32,580	15.8	93,960	25.7	155,340	35.6	216,720
6.0	33,200	15.9	94,580	25.8	155,960	35.7	207,340
6.1	33,820	16.0	95,200	25.9	156,580	35.8	217,960
6.2	34,440	16.1	95,820	26.0	157,200	35.9	218,580
6.3	35,060	16.2	96,440	26.1	159,820	36.0	219,200
6.4	35,680	16.3	97,060	26.2	158,440	36.1	219,820
6.5	36,300	16.4	97,680	26.3	159,060	36.2	220,440
6.6	36,920	16.5	98,300	26.4	159,680	36.3	221,060
6.7	37,540	16.6	98,920	26.5	160,300	36.4	221,680
6.8	38,160	16.7	99,540	26.6	160,920	36.5	222,300
6.9	38,780	16.8	100,160	26.7	161,540	36.6	222,920
7.0	39,400	16.9	100,780	26.8	162,160	36.7	223,540
7.1	40,020	17.0	101,400	26.9	162,780	36.8	224,160
7.2	40,640	17.1	102,020	27.0	163,400	36.9	224,780
7.3	41,260	17.2	102,640	27.1	164,020	37.0	225,400
7.4	41,880	17.3	103,260	27.2	164,640	37.1	226,020
7.5	42,500	17.4	103,880	27.3	165,260	37.2	226,640
7.6	43,120	17.5	104,500	27.4	165,880	37.3	227,260
7.7	43,740	17.6	105,120	27.5	166,500	37.4	227,880
7.8	44,360	17.7	105,740	27.6	167,120	37.5	228,500
7.9	44,980	17.8	106,360	27.7	167,740	37.6	229,120
8.0	45,600	17.9	106,980	27.8	168,360	37.7	229,740
8.1	46,220	18.0	107,600	27.9	168,980	37.8	230,360
8.2	46,840	18.1	108,220	28.0	169,600	37.9	230,980
8.3	47,460	18.2	108,840	28.1	170,220	18.0	231,600
8.4	48,080	18.3	109,460	28.2	170,840	38.1	232,220
8.5	48,700	18.4	110,080	28.3	171,460	38.2	232,840
8.6	49,320	18.5	110,700	28.4	172,080	38.3	233,460
8.7	49,940	18.6	111,320	28.5	172,700	38.4	234,080
8.8	50,560	18.7	111,940	28.6	173,320	38.5	234,700
8.9	51,180	18.8	112,560	28.7	173,940	38.6	235,320
9.0	51,800	18.9	113,180	28.8	174,560	38.7	235,940
9.1	52,420	19.0	113,800	28.9	175,180	38.8	236,560
9.2	53,040	19.1	114,420	29.0	175,800	38.9	237,180
9.3	53,660	19.2	115,040	29.1	176,420	39.0	237,800
9.4	54,280	19.3	115,660	29.2	177,040	39.1	238,420
9.5	54,900	19.4	116,280	29.3	177,660	39.2	239,040
9.6	55,520	19.5	116,900	29.4	178,280	39.3	239,660
9.7	56,140	19.6	117,520	29.5	178,900	39.4	240,280
9.8	56,760	19.7	118,140	29.6	179,520	39.5	240,900
9.9	57,380	19.8	118,760	29.7	180,140	39.6	241,520
10.0	58,000	19.9	119,380	29.8	180,760	39.7	242,140
10.1	58,620	20.0	120,000	29.9	181,380	39.8	242,760
10.2	59,240	20.1	120,620	30.0	182,000	39.9	243,380
10.3	59,860	20.2	121,240	30.1	182,620	40.0	244,000

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
10.4	60,480	20.3	121,860	30.2	183,240		
10.5	61,100	20.4	122,480	30.3	183,860		
10.6	61,720	20.5	123,100	30.4	184,480		

NOTE—This table applied to the foregoing "daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

The following discharge measurements were made on the Tennessee River at Chattanooga, Tenn., during 1901:

1901.

Jan. 24—Hydrographer, Max Hall: Gage height, 5.60 feet; discharge, 30,317 second-feet.

April 4—Hydrographer, K. T. Thomas: Gage height, 24.20 feet; discharge, 155,457 second-feet.

July 31—Hydrographer, K. T. Thomas: Gage height, 2.80 feet; discharge, 15,393 second-feet.

Aug. 18—Hydrographer, K. T. Thomas: Gage height, 31.70 feet; discharge, 198,718 second-feet.

Daily gage height of Tennessee River at Chattanooga, Tenn., for 1901.

Day	Jan.	Feb.	Mar.	April	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec
1..........	5.2	6.5	3.7	12.4	10.8	12.0	6.0	2.8	9.9	4.2	2.6	2.3
2..........	5.7	6.7	3.7	13.2	9.3	11.1	5.9	2.8	9.8	4.5	2.6	2.2
3..........	5.8	7.2	3.7	19.7	8.5	9.8	6.3	2.9	9.7	4.6	2.5	2.3
4..........	5.6	8.7	3.7	24.1	7.6	8.5	6.4	2.8	10.3	4.5	2.5	2.5
5..........	5.1	10.1	3.8	23.9	7.0	7.7	6.0	2.6	9.4	4.4	2.5	2.5
6..........	4.7	10.0	4.0	22.4	6.7	6.9	5.2	2.6	7.9	4.8	2.5	2.5
7..........	4.4	9.4	4.1	18.9	6.4	6.9	5.1	3.2	6.9	4.5	2.4	3.0
8..........	4.1	8.9	4.1	14.2	6.2	6.9	5.4	9.1	6.4	4.1	2.4	3.2
9..........	3.9	8.5	4.0	11.8	5.9	6.5	5.6	12.2	5.9	3.9	2.4	3.2
10..........	3.8	7.1	7.0	10.3	5.6	6.9	6.3	9.9	5.5	3.7	2.1	3.5
11..........	6.1	7.6	9.8	9.2	5.6	8.2	6.6	7.3	5.3	3.4	2.4	3.5
12..........	15.4	7.0	11.2	8.4	5.4	7.4	5.6	5.8	5.1	3.4	2.4	4.0
13..........	26.6	7.1	9.7	7.9	5.6	6.4	5.0	5.3	5.7	3.5	2.5	4.1
14..........	28.1	7.2	8.2	6.8	5.5	6.1	4.4	6.5	5.9	4.0	2.5	4.7
15..........	25.3	7.0	7.3	9.8	5.5	6.4	4.1	14.0	6.0	4.3	2.5	17.9
16..........	19.5	6.4	6.4	10.3	5.4	7.5	3.6	27.3	6.1	4.1	2.5	26.8
17..........	12.7	5.8	5.8	10.2	5.2	8.9	3.7	32.8	6.3	4.1	2.4	28.8
18..........	9.7	5.3	5.4	9.6	4.9	9.8	3.9	32.6	8.8	4.0	2.4	26.7
19..........	8.1	5.1	5.0	10.8	5.3	9.3	3.7	28.6	9.9	3.7	2.3	19.9
20..........	7.2	5.0	4.7	21.1	8.0	8.9	3.7	23.4	9.3	3.3	2.3	11.4
21..........	6.4	4.9	4.7	26.5	10.2	8.4	4.2	18.6	8.3	3.1	2.2	8.3
22..........	5.9	4.7	4.8	24.7	20.2	7.7	3.9	17.0	7.4	3.1	2.1	6.6
23..........	5.4	4.5	5.2	23.0	26.5	10.1	3.7	16.5	6.4	3.1	2.2	5.7
24..........	5.6	4.4	5.0	22.2	29.7	9.5	3.5	18.5	5.6	3.0	2.5	5.8
25..........	5.8	4.2	5.0	19.0	32.4	7.6	3.1	16.5	5.2	3.0	2.5	6.9
26..........	5.8	4.1	7.7	17.1	32.5	9.6	3.0	13.1	4.9	2.9	2.5	7.9
27..........	5.4	3.8	15.9	14.9	23.5	9.8	2.9	11.0	4.6	2.8	2.6	10.2
28..........	5.2	3.7	22.3	14.9	13.5	8.4	2.9	10.3	4.4	2.7	2.5	16.0
29..........	5.2	......	21.7	14.5	12.1	7.2	2.8	10.7	4.4	2.6	2.5	21.0
30..........	5.2	......	18.4	13.8	11.9	6.4	2.8	10.0	4.3	2.5	2.4	32.0
31..........	5.5	......	14.7	......	12.3	....	2.8	9.8	......	2.5	......	37.4

Rating table of Tennessee River at Chattanooga, Tennessee, for 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second ft.*
2.0	11,250	11.6	69,600	21.2	132,000	30.8	194,400
2.1	11,660	11.7	70,250	21.3	132,650	30.9	195,050
2.2	12,080	11.8	70,900	21.4	133,300	31.0	195,700
2.3	12,500	11.9	71,550	21.5	133,950	31.1	196,350
2.4	12,930	12.0	72,200	21.6	134,600	31.2	197,000
2.5	13,360	12.1	72,850	21.7	135,250	31.3	197,650
2.6	13,800	12.2	73,500	21.8	135,900	31.4	198,300
2.7	14,240	12.3	74,150	21.9	136,550	31.5	198,950
2.8	14,680	12.4	74,800	22.0	137,200	31.6	199.600
2.9	15,140	12.5	75,450	22.1	137,850	31.7	200,250
3.0	15,600	12.6	76,100	22.2	138,500	31.8	200,900
3.1	16,080	12.7	76,750	12.3	139,150	31.9	201.550
3.2	16,550	12.8	77,400	22.4	139,800	32.0	202,200
3.3	17,050	12.9	78,050	22.5	140,450	32.1	202,850
3.4	17,550	13.0	78,700	22.6	141,100	32.2	203,500
3.5	18,050	13.1	79,350	22.7	141,750	32.3	204,150
3.6	18,550	13.2	80,000	22.8	142,400	32.4	204,800
3.7	19,050	13.3	80,650	22.9	143,050	32.5	205,450
3.8	19,600	13.4	81,300	23.0	143,700	32.6	206,100
3.9	20,200	13.5	81,950	23.1	144,350	32.7	206,750
4.0	20,800	13.6	82,600	23.2	145,000	32.8	207,400
4.1	21,420	13.7	83,250	23.3	145,650	32.9	208,050
4.2	22.040	13.8	83,900	23.4	146,300	33.0	208.700
4.3	22,660	13.9	84,550	23.5	146,950	33.1	209,350
4.4	23,280	14.0	85,200	23.6	147,600	33.2	210,000
4.5	23,900	14.1	85,850	23.7	148,250	33.3	210.650
4.6	24,520	14.2	86,500	23.8	148,900	33.4	211,300
4.7	25,140	14.3	87,150	23.9	149,550	33.5	211,950
4.8	25,760	14.4	87,800	24.0	150,200	33.6	212,600
4.9	26,380	14.5	88,450	24.1	150,850	33.7	213,250
5.0	27,000	14.6	89,100	24.2	151,500	33.8	213,900
5.1	27,620	14.7	89,750	24.3	152,150	33.9	214,550
5.2	28,240	14.8	90,400	24.4	152,800	34.0	215.200
5.3	28,860	14.9	91,050	24.5	153,450	34.1	215,850
5.4	29,480	15.0	91.700	24.6	154,100	34.2	216.500
5.5	30,100	15.1	92.350	24.7	154,750	34.3	217.150
5.6	30,720	15.2	93.000	24.8	155,400	34.4	217.800
5.7	31,340	15.3	93,650	24.9	156,050	34.5	218.450
5.8	31,960	15.4	94,300	25.0	156,700	34.6	219,100
5.9	32,580	15.5	94,950	25.1	157,350	34.7	219,750
6.0	33,200	15.6	95,600	25.2	158,000	34.8	220.400
6.1	33,850	15.7	96,250	25.3	158,650	34.9	221.050
6.2	34.500	15.8	96.900	25.4	159,300	35.0	221.700
6.3	35.150	15.9	97,550	25.5	159.950	35.1	222 350
6.4	35,800	16.0	98,200	25.6	160,600	35.2	223.000
6.5	36,450	16.1	98.850	25.7	161,250	35.3	223.650
6.6	37,100	16.2	99,500	25.8	161,900	35.4	224.300
6.7	37.750	16.3	100,150	25.9	162.550	35.5	224.950

Rating table for Tennessee River at Chattanooga, Tenn., for 1901.

Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.	Gage height.	Discharge.
Feet.	*Second Ft.*	*Feet.*	*Second Ft.*	*Feet.*	*Second ft.*	*Feet.*	*Second Ft.*
6.8	38,400	16.4	100,800	26.0	163,200	35.6	225,600
6.9	39,050	16.5	101,450	26.1	163,850	35.7	226,250
7.0	39,700	16.6	102,100	26.2	164,500	35.8	226,900
7.1	40,350	16.7	102,750	26.3	165,150	35.9	227,550
7.2	41,000	16.8	103,400	26.4	165,800	36.0	228,200
7.3	41,650	16.9	104,050	26.5	166,450	36.1	228,850
7.4	42,300	17.0	104,700	26.6	167,100	36.2	229,500
7.5	42,950	17.1	105,350	26.7	167,750	36.3	230,150
7.6	43,600	17.2	106,000	26.8	168,400	36.4	230,800
7.7	44,250	17.3	106,650	26.9	169,050	36.5	231,450
7.8	44,900	17.4	107,300	27.0	169,700	36.6	232,100
7.9	45,550	17.5	107,950	27.1	170,350	36.7	232,750
8.0	46,200	17.6	108,600	27.2	171,000	36.8	233,400
8.1	46,850	17.7	109,250	27.3	171,650	36.9	234,050
8.2	47,500	17.8	109,900	27.4	172,300	37.0	234,700
8.3	48,150	17.9	110,550	27.5	172,950	37.1	235,350
8.4	48,800	18.0	111,200	27.6	173,600	37.2	236,000
8.5	49,450	18.1	111,850	27.7	174,250	37.3	236,650
8.6	50,100	18.2	112,500	27.8	174,900	37.4	237,300
8.7	50,750	18.3	113,150	27.9	175,550	37.5	237,950
8.8	51,400	18.4	113,800	28.0	176,200	37.6	238,600
8.9	52,050	18.5	114,450	28.1	176,850	37.7	239,250
9.0	52,700	18.6	115,100	28.2	177,500	37.8	239,900
9.1	53,350	18.7	115,750	28.3	178,150	37.9	240,550
9.2	54,000	18.8	116,400	28.4	178,800	38.0	241,200
9.3	54,650	18.9	117,050	28.5	179,450	38.1	241,850
9.4	55,300	19.0	117,700	28.6	180,100	38.2	242,500
9.5	55,950	19.1	118,350	28.7	180,750	38.3	243,150
9.6	56,600	19.2	119,000	28.8	181,400	38.4	243,800
9.7	57,250	19.3	119,650	28.9	182,050	38.5	244,450
9.8	57,900	19.4	120,300	29.0	182,700	38.6	245,100
9.9	58,550	19.5	120,950	29.1	183,350	38.7	245,750
10.0	59,200	19.6	121,600	29.2	184,000	38.8	246,400
10.1	59,850	19.7	122,250	29.3	184,650	38.9	247,050
10.2	60,500	19.8	122,900	29.4	185,300	39.0	247,700
10.3	61,150	19.9	123,550	29.5	185,950	39.1	248,350
10.4	61,800	20.0	124,200	29.6	186,600	39.2	249,000
10.5	62,450	20.1	124,850	29.7	187,250	39.3	249,650
10.6	63,100	20.2	125,500	29.8	187,900	39.4	250,300
10.7	63,750	20.3	126,150	29.9	188,550	39.5	250,950
10.8	64,400	20.4	126,800	30.0	189,200	39.6	251,600
10.9	65,050	20.5	127,450	30.1	189,850	39.7	252,250
11.0	65,700	20.6	128,100	30.2	190,500	39.8	252,900
11.1	66,350	20.7	128,750	30.3	191,150	39.9	253,550
11.2	67,000	20.8	129,400	30.4	191,800	40.0	254,200
11.3	67,650	20.9	130,050	30.5	192,450		
11.4	68,300	21.0	130,700	30.6	193,100		
11.5	68,950	21.1	131,350	30.7	193,750		

NOTE—This table applied to the foregoing "daily gage heights" gives the cubic feet per second flowing in the river on each date for which the gage height is given.

Estimated monthly discharge of Tennessee River at Chattanooga, Tennessee.

[Drainage area, 21,382 square miles.]

Month.	Discharge in second-feet				Run-off.	
	Maximum.	Minimum.	Mean.	Total in acre-feet.	Depth in inches.	Second-feet per square mile.
1890.						
January	78,470	30,150	42,749	2,628,551	2.31	2.00
February	308,060	44,191	76,081	4,225,310	3.72	3.56
March	445,120	52,906	129,093	7,937,670	6.96	6.03
April	121,464	43,029	64,855	3,859,132	3.38	3.03
May	72,079	41,286	51,200	3,148,186	2.76	2.39
June	41,286	23,400	29,102	1,731,685	1.52	1.36
July	47,677	19,500	27,036	1,662,390	1.45	1.26
August	46,515	21,100	30,881	1,898,810	1.66	1.44
September	47,096	22,200	27,843	1,656,770	1.45	1.30
October	58,135	25,950	37,982	2,335,437	2.04	1.77
November	42,448	20,700	26,394	1,570,549	1.37	1.23
December	77,889	20,400	36,088	2,218,980	1.95	1.69
Per annum	445,120	19,500	48,275	34,873,470	30.57	2.26
1891.						
January	92,995	39,543	59,484	3,657,552	3.21	2.78
February	356,120	59,878	154,822	8,598,380	7.53	7.23
March	381,040	63,364	135,160	8,310,718	7.30	6.32
April	97,643	38,962	61,873	3,681,690	3.22	2.89
May	37,219	26,380	30,215	1,857,860	1.63	1.41
June	47,096	26,840	36,276	2,158,567	1.90	1.70
July	36,057	21,800	26,429	1,625,066	1.43	1.24
August	98,224	23,000	40,402	2,484,238	2.18	1.89
September	36,638	19,200	25,777	1,533,835	1.34	1.20
October	19,200	17,910	18,461	1,135,130	.99	.86
November	41,867	17,440	23,510	1,398,939	1.23	1.10
December	66,269	22,200	39,299	2,416,417	2.12	1.84
Per annum	381,040	17,440	54,309	38,858,392	34.08	2.54
1892.						
January	363,240	41,286	103,453	6,361,118	5.57	4.83
February	69,755	33,733	46,755	2,689,348	2.43	2.25
March	64,526	31,680	45,769	2,814,244	2.47	2.14
April	299,160	40,705	101,287	6,026,982	5.27	4.73
May	53,487	31,160	39,772	2,445,501	2.14	1.86
June	56,972	28,680	43,265	2,574,447	2.25	2.02
July	71,498	26,380	44,520	2,737,446	2.40	2.08
August	31,680	21,800	25,121	1,544,640	1.35	1.17
September	29,660	17,660	21,403	1,273,564	1.11	1.00
October	19,800	17,220	17,952	1,103,833	.97	.84
November	43,610	17,220	27,924	1,661,590	1.45	1.30
December	56,972	21,450	32,793	2,016,376	1.76	1.53
Per annum	363,240	17,220	45,835	33,249,089	29.17	2.15

Estimated monthly discharge of Tennessee River at Chattanooga, Tennessee—Continued.

[Drainage area, 21,382 square miles.]

Month.	Discharge in second-feet.			Total in acre-ft.	Run-off.	
	Maximum.	Minimum.	Mean.		Depth in inches.	Second-ft. per sq. mile.
1893.						
January	44,191	22,600	26,812	1,648,616	1.44	1.25
February	283,140	38,381	105,921	5,882,535	5.15	4.95
March	72,660	36,057	50,320	3,094,076	2.71	2.35
April	73,241	31,160	42,137	2,507,326	2.20	1.97
May	224,400	30,150	71,525	4,397,929	3.85	3.34
June	123,207	27,760	49,679	2,956,099	2.59	2.32
July	34,895	21,450	25,741	1,582,763	1.38	1.20
August	33,152	18,410	23,477	1,443,554	1.27	1.10
September	76,727	20,750	33,933	2,019,149	1.77	1.59
October	58,716	18,660	25,550	1,571,018	1.37	1.19
November	31,160	20,400	22,263	1,324,738	1.16	1.04
December	30,640	21,100	24,970	1,535,355	1.35	1.17
Per annum	283,140	18,410	41,861	29,963,158	26.24	1.96
1894.						
January	56,972	22,600	37,389	2,298,975	2.02	1.75
February	151,095	31,680	70,893	3,937,185	3.45	3.31
March	59,297	33,152	46,796	2,877,392	2.53	2.19
April	52,325	27,300	36,287	2,159,222	1.90	1.70
May	44,191	23,800	31,137	1,914,552	1.68	1.43
June	28,680	19,500	21,983	1,308,076	1.15	1.03
July	29,170	18,910	24,486	1,505,595	1.31	1.14
August	30,150	18,910	22,971	1,412,441	1.23	1.07
September	27,300	16,560	19,160	1,140,097	1.00	.90
October	20,750	16,360	17,445	1,072,658	.94	.82
November	20,400	16,360	17,330	1,031,204	.90	.81
December	68,012	16,780	30,862	1,897,643	1.66	1.44
Per annum	151,095	16,360	31,395	22,555,040	19.77	1.53
1895.						
January	261,780	23,400	76,446	4,700,512	4.12	3.57
February	47,096	24,200	35,787	1,987,503	1.74	1.67
March	134,827	42,448	72,341	4,448,103	3.90	3.38
April	78,470	37,219	51,047	3,037,501	2.67	2.39
May	58,135	34,314	43,929	2,701,106	2.37	2.05
June	35,476	21,100	26,417	1,651,917	1.37	1.23
July	63,364	20,750	29,638	1,822,381	1.60	1.39
August	38,381	21,800	26,927	1,655,687	1.45	1.26
September	24,660	16,780	20,316	1,208,883	1.05	.95
October	17,000	16,360	16,665	1,024,698	.90	.78
November	20,750	17,220	18,162	1,080,714	.94	.85
December	33,152	17,660	21,561	1,325,743	1.16	1.01
Per annum	261,780	16,360	36,603	26,564,748	23.27	1.71

Estimated monthly discharge of Tennessee River at Chattanooga, Tennessee—Continued.

[Drainage area, 21,418 square miles.]

Month.	Discharge in second-feet. Maximum.	Minimum.	Mean	Total in acre-feet.	Run-off. Depth in inches.	Second-ft. per sq. mile.
1896.						
January	50,600	15,554	26,169	1,609,079	1.41	1.22
February	85,052	26,840	55,577	3,196,826	2.79	2.59
March	95,150	22,088	39,257	2,413,834	2.11	1.83
April	409,520	23,276	87,649	5,215,478	4.56	4.09
May	29,216	14,366	20,574	1,265,054	1.10	0.96
June	43,472	17,336	24,365	1,449,815	1.27	1.14
July	130,196	20,306	55,390	3,405,820	2.99	2.59
August	34,562	14,960	22,433	1,379,360	1.21	1.05
September	18,524	9,020	12,346	734,636	.64	.58
October	19,712	8,426	11,588	712,523	.62	.54
November	57,728	9,020	22,603	1,344,969	1.18	1.06
December	45,254	16,148	27,951	1,718,651	1.51	1.31
The year	409,520	8,426	33,825	24,446,045	21.39	1.58
1897.						
January	45,254	16,148	27,932	1,717,483	1.50	1.30
February	308,060	19,712	89,962	4,996,236	4.37	4.20
March	363,240	52,976	165,448	10,173,067	8.90	7.72
April	231,520	36,344	81,056	4,823,156	4.22	3.78
May	134,948	26,543	50,124	3,082,025	2.70	2.34
June	38,126	21,494	29,107	1,731,983	1.52	1.36
July	74,657	21,791	34,428	2,116,909	1.86	1.61
August	34,562	14,366	25,847	1,589,280	1.39	1.21
September	14,960	6,050	8,951	532,620	.47	.42
October	13,772	4,268	7,842	482,189	.43	.37
November	9,614	6,050	7,330	436,164	.38	.34
December	62,183	8,129	24,627	1,514,265	1.33	1.15
The year	363,240	4,268	46,055	33,195,377	29.07	2.15
1898.						
January	124,860	14,344	59,509	3,778,785	3.20	2.77
February	47,115	16,900	22,994	1,277,022	1.11	1.07
March	88,725	15,008	24,774	1,523,304	1.28	1.11
April	121,940	39,085	60,048	3,573,096	3.12	2.80
May	38,720	17,920	23,701	1,457,327	1.28	1.11
June	32,515	10,245	16,395	975,569	.85	.77
July	49,670	11,853	20,063	1,233,633	1.08	.94
August	107,705	20,410	50,638	3,113,629	2.72	2.36
September	174,500	18,190	47,349	2,817,454	2.46	2.21
October	115,370	16,900	44,215	2,718,691	2.38	2.06
November	42,005	20,700	28,415	1,690,806	1.48	1.33
December	35,800	19,000	28,909	1,777,556	1.56	1.35
The year	174,500	10,245	35,584	25,936,872	22.52	1.66

Estimated monthly discharge of Tennessee River at Chattanooga, Tennessee—Continued.

[Drainage area, 21,418 square miles.]

Month.	Discharge in second-feet. Maximum.	Discharge in second-feet. Minimum.	Discharge in second-feet. Mean.	Total in acre-feet.	Run-off. Depth in inches.	Run-off. Second-feet per square mile.
1899.						
January	112,560	25,450	47,250	2,905,289	2.55	2.21
February	233,150	30,720	95,554	5,306,801	4.64	4.46
March	244,000	55,210	142,700	8,774,281	7.68	6.66
April	137,360	39,710	69,286	4,122,803	3.59	3.23
May	65,130	22,040	40,450	2.487,173	2.18	1.89
June	35,990	15,600	23,088	1,373,831	1.20	1.08
July	27,930	10,430	15,053	925,573	.81	.70
August	22,040	8,040	11,900	731,702	.64	.56
September	15,840	7,300	10,118	603,063	.53	.47
October	10,635	6,600	7,851	482,739	.43	.37
November	10,635	6,775	8,216	488,886	.43	.38
December	41,880	8,820	22,061	1,356,478	1.19	1.03
The year	244,000	6,600	41,127	29,557,619	25.87	1.09
1900.						
January	54,280	11,660	30,807	1,894,248	1.66	1.44
February	144,800	13.360	52,077	2,892,210	2.53	2.43
March	103,880	42,810	66,020	4,059,412	3.55	3.08
April	70,400	32,820	46,819	2,785,924	2.44	2.19
May	34,440	15,600	21,086	1,296,528	1.13	.98
June	53,040	14,680	33,295	1,981,190	1.73	1.55
July	50,870	13,360	24,674	1,517,145	1.33	1.15
August	34,440	10,020	14,602	897,841	.78	.68
September	25,140	7,300	13,393	796,939	.70	.63
October	42,500	8,040	14,230	874,968	.76	.66
November	92,720	10,840	25,138	1,495,815	1.31	1.17
December	53,040	17,050	29,001	1.783,201	1.56	1.35
The year	144,800	7,300	30,928	22.275,421	19.48	1.44
1901.						
January	189,200	19,600	50,641		2.72	2.36
February	59,850	19,050	36.516		1.77	1.70
March	139,150	19,050	44,952		2.42	2.10
April	166,450	38,400	95.080		4.95	4.44
May	205,450	26,380	68.736		3.70	3.21
June	72,200	33,850	47,673		2.49	2.23
July	37.100	14,680	23.932		1.29	1.12
August	207.400	13.800	75,761		4.08	3.54
September	61.150	22,660	38.859		2.02	1.81
October	25.760	13,360	18.979		1.03	.89
November	13,800	11,660	13,076		.68	.61
December	237.300	12,080	65.509		3.53	3.06
The year	237,200	11,660	48,310		30.68	2.26

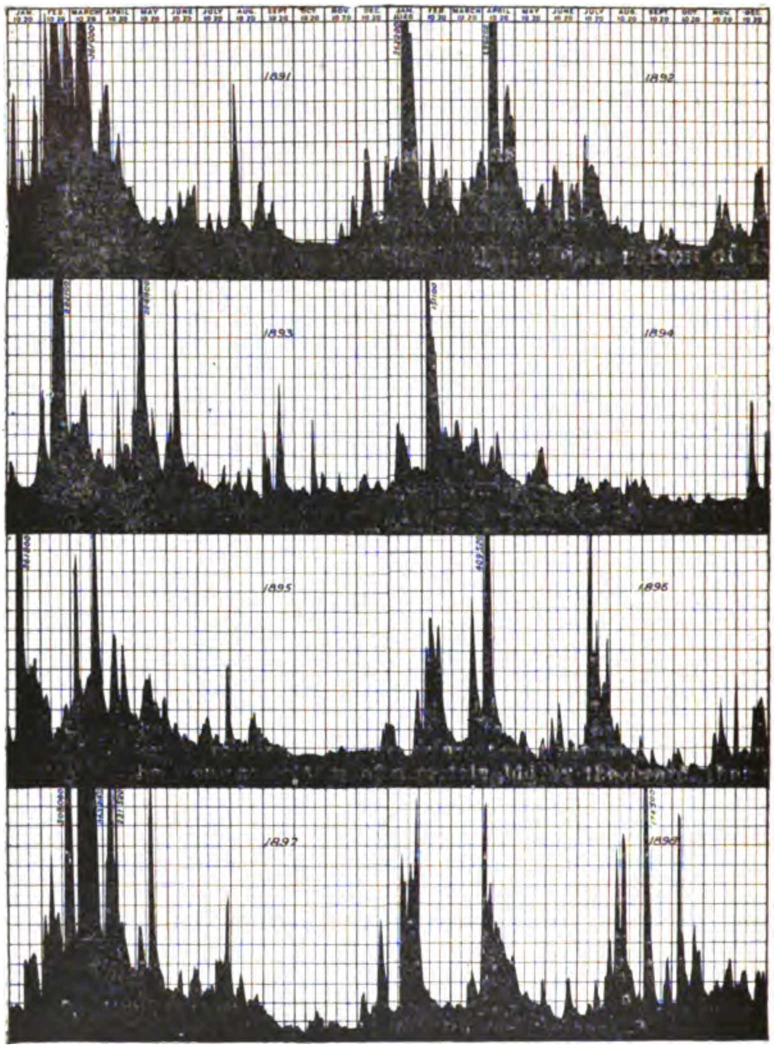

Fig. 16—Discharge of Tennessee River at Chattanooga, Tenn, 1891-1898.

Minimum monthly discharge of Tennessee River at Chattanooga, Tenn., with corresponding net horsepower per foot of fall on a water wheel realizing 80 per cent. of the theoretical power.

	1899.			1900.			1901		
	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot of fall.	No. of days duration of minimum.	Minimum cubic feet per second.	Minimum net H. P. per foot fall.	No. of days duration of minimum.
January	25,450	2,314	1	11,660	1,060	1	19,600	1,782	1
February ...	30,720	2,793	1	13,360	1,215	1	19,050	1,732	1
March	55,210	5,019	1	42,810	3,892	2	19,050	1,732	4
April	39,710	3,610	1	32,820	3,075	1	38,400	3.491	1
May	22,040	2,004	1	15,600	1,418	1	26,380	2,398	1
June	15,600	1,418	1	14,680	1,335	1	33,850	3.077	1
July	10,430	948	1	13,360	1,215	2	14.680	1,335	3
August	8,040	731	3	10,020	911	1	13,800	1.255	2
September ..	7,300	664	1	7,300	664	1	22.660	2,060	1
October	6,600	600	3	8,040	731	2	13,360	1,215	2
November ..	6,775	616	2	10,840	985	2	11,660	1,060	1
December ..	8,820	802	2	17,050	1,550	2	12,080	1,098	1

NOTE—To find the minimum net horse power available at a shoal on this stream, near this station, for any month, multiply the total fall of the shoal by the "net H. P. per foot of fall" in this table for that month.

2. SHOALS IN TENNESSEE RIVER NEAR FLORENCE, ALABAMA.

In Tennessee River, in the vicinity of Florence, Ala., (see Fig. 96), are several shoals capable of the development of power in large quantities. The compiler has brought together the data regarding these, his intention being not to discuss the manner in which the immense water power of these shoals can be developed, but to give some idea of its magnitude and the possibility of its utilization.

The shoals are a succession of cascades amid many islands, in a river bed varying in width from a half mile to three miles. The numerous channels thus formed are very irregular in fall and direction. The difference between high and low water is only 5 or 6 feet, corresponding to a rise of 50 feet at Chattanooga. Beginning at Brown's Ferry, 12 miles below Decatur, Ala., the river has the following falls:

From Browns Ferry to the mouth of Elk River the fall is 26 feet in 11 miles. This is known as Elk River Shoals. Its most precipitous part is at the lower end, where there is a fall of 16.5 feet in about 4 miles.

From the mouth of Elk River to the head of Muscle Shoals, a distance of 5 miles, there is a fall of only 2 feet.

From the head of Muscle Shoals to Bainbridge the fall is 85 feet in 17 miles, and is known as Big Muscle Shoals.

From Bainbridge to Florence the fall is 23 feet in 7 miles, and is known as Little Muscle Shoals.

From Florence to the head of the Colbert Shoals the fall is 3 feet in 11 miles.

From the head of the Colbert Shoals to Waterloo the fall is 21 feet in 6 miles.

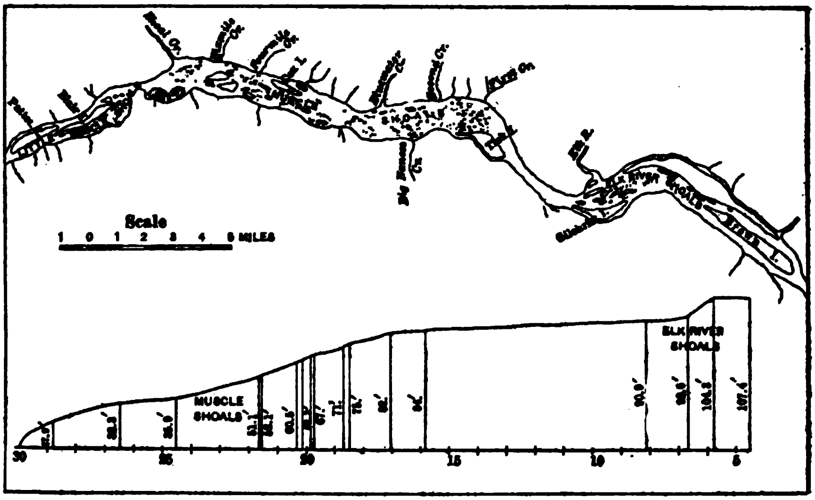

Fig. 17.—Map showing shoals in Tennessee River, near Florence, Ala.

The total fall from Browns Ferry to Waterloo is, therefore, 160 feet in a distance of 57 miles. Sixteen miles of the distance, howeer, has a fall of only 5 feet, leaving a fall of 155 feet in the 41 miles that cover the four shoals mentioned. The shoals are really more precipitous than the foregoing figures would indicate. For instance, 84.6 feet of the fall at Big Muscle Shoals is in a distance of 14 miles.

The bed rock at Elk River Shoals is Carboniferous limestone; that of Muscle Shoals is a hard silicous rock of dark color and flinty structure.

The following is a statement of the minimum discharge of Tennessee River at Chattanooga:

*The numbers 5 to 30 at bottom of cut represent miles.

	Sec.-ft.
From 1890 to 1895, inclusive	16..
From 1896 to 1900, inclusive	6,600
From January 1 to November 16, 1901, inclusive	12,930

From this it is estimated that 6,600 second-feet is the minimum discharge for driest years, and that 12,930 second-feet is the minimum for average years. Assuming that tributaries entering the river below Chattanooga will safely supply all of the water needed for lockage, we can use these discharges in estimating the water power of these shoals, which are about 200 miles below Chattanooga, by river, and drain an area more than 7,000 square miles greater than the watershed above Chattanooga.

Estimated minimum net horsepower of Tennessee River in Alabama on turbines realizing 80 per cent. of the theoretical power.

Locality.	Fall	Minimum net power in driest years.	Minimum net power in average years.
	Fall.	*Horsepower.*	*Horsepower.*
Elk River Shoals	26	15,600	30,050
Big Muscle Shoals	85	51,000	99,875
Little Muscle Shoals	23	13,800	27,025
Colbert Shoals	21	12,600	24,675
Total	155	93,000	182,125

The foregoing table assumes that the total fall can in each case be utilized. While this assumption is not correct, it stands as an offset to the assumption that the water supply available will be as low as the minimum discharge at Chattanooga, 200 miles above. The drainage area above Chattanooga is 21,418 square miles, while the drainage area above the shoals under consideration is about 29,000 square miles. It may therefore safely be assumed that the actual power available for development at the shoals is greater than that shown by the table.

The foregoing statements of fall and distance are from a report by Mr. William B. Gaw, chief assistant engineer, United States Army, 1868, and the map and profile are from drawings prepared under the direction of Lieut. Col. J. W. Barlow, United States Engineers, 1890.

3. TRIBUTARIES OF TENNESSEE RIVER.

Paint Rock Creek, Elk River, Shoal Creek, Flint Creek, Big Nance Creek, Town Creek, and Big Bear Creek are all large streams, and most of them have fine undeveloped water powers. But no surveys have been made of them, and no measurements of discharge so far. There are also many large bold springs in this basin, that are said to have a pure and unfailing water supply, but the Hydrographic Survey has not reached them, and no report can be made on them at this time.

Plate D. Dam of the Pratt Gin Company, on Autauga Creek, Prattville, Ala.

CHAPTER VIII.

UTILIZED WATER POWERS OF ALABAMA.

The following is a list by counties of the water powers that are utilized. The most of these powers are small, but they make a large aggregate, and they represent only an insignificant part of the power that is capable of development.

*AUTAUGA COUNTY.

	NAME.	POSTOFFICE.	INDUSTRY.	H. P.
*	Charity P. Carter	Billingsley	flour and grist mill	15
*	Montgomery's Mill	Prattville	flour and grist mill	30
*	Public Grist Mill	Billingsley	flour and grist mill	9
*	Parker's Mill	Milton	flour and grist mill	20
*	Dawson's Mill	Netezen	lumber and timber mill	20
*	Ellis Mill	Jones Switch	lumber and timber mill	4
*	Long Leaf Yellow Pine Saw Mill	Autaugaville	lumber and timber mill	15
*	Ray's Saw Mill	Jones Switch	lumber and timber mill	10
*	Swift Creek Mill Co. (Swift Creek)	Autaugaville	lumber and timber mill	70
*	John H. Herod	Netezen	lumber and timber mill	6
*	Prattville Cotton M. & Banking Co. (Autauga Creek)	Prattville	cotton goods. The dam at Prattville is shown in Plate D opposite	200
†	Continental Gin Co., (Autauga Creek)	Prattville	cotton gin	
†	Prattville Ice Factory (Autauga Creek)	Prattville	ice factory	
†	Doster Ginnery (Autauga Creek)	Prattville	cotton gin	
†	G. H. Roy	Vine Hill	cotton gin	

WATER POWER AT PRATTVILLE.

The water power at Prattville was first developed about 1830, when it was used by a man named May to operate a small saw mill. About 1833 this water power and the adjacent lands were purchased by Mr. Daniel Pratt, who then erected a cotton gin factory, which was driven by the water power. The dam at that time was about eight feet high. A number of years after the purchase of this property by Mr. Pratt he increased the dam so that it now has a height of 16 feet, and is built of brick. At present it is used jointly by the Prattville Cotton Mills & Banking Company and the Continental Gin Company, the former using about 255 horse-power and the latter about 100 horse-power. About half a mile below the dam above referred to is another dam affording about 8 feet head, and owned by the M. E. Pratt estate. This power operates a grist

*From U. S. Census, 1900.
†From report of Probate Judge.

mill, cotton ginnery and ice factory, and the water wheel at that point has a rated capacity of 54 horse-power. About one mile above the dam of the Cotton Mill and Gin Company, there was formerly another dam 12 feet high, which afforded power for a cotton mill. This mill, however, was burned a number of years ago, and the dam has been allowed to go to ruin. It would probably afford 200 horse-power, or possibly a little more, should it be rebuilt.

There is also a dam about two miles below Prattville known as the Montgomery mill property. This dam is about 12 feet high and affords power for a grist mill and ginnery. Only a small portion of the available power is used. It could afford, easily, 250 horse-power if the proper wheels were installed.

*BARBOUR COUNTY.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
Hagler's Mill	Louiville	flour and grist mill	17
Carpenter's Mill	Louisville	flour and grist mill	15
Hoffman's Mill	Clayton	flour and grist mill	50
Hartman's Mill	Clayton	flour and grist mill	10
Zorn Mills	Lodi	flour and grist mill	8
William M. Wood	Bush	flour and grist mill	12
Will Stewart	White Oak Springs	flour and grist mill	12
Winn's Mill	Clayton	flour and grist mill	12
John White	Spivey	flour and grist mill	10
Weston's Mill	Louisville	flour and grist mill	8
H. J. Turner	White Oak Springs	flour and grist mill	10
Spencer's Mill	Clayton	flour and grist mill	10
Perkin's Mill	Elamville	flour and grist mill	12
Angus McSwain	White Oak Springs	flour and grist mill	12
William Johnson	Clayton	flour and grist mill	10
John M. Jenkins	Starhill	flour and grist mill	10
Solomon's Mills	Solomon's Mills	flour and grist mill	25
Danner Mill	Elamville	flour and grist mill	12
William H. Chambers	Oateston	flour and grist mill	12
Wilson Deshazo	Cottonhill	flour and grist mill	16

BIBB COUNTY.

	NAME.	POSTOFFICE.	INDUSTRY.	H. P.
*	Scottsville Flour & Grist Mill	Scottsville	flour and grist mill	30
	Palmetto Flouring & Grist Mill	Brierfield	flour and grist mill	30
	Williams Grist Mill	Blocton	flour and grist mill	10
	William S. Mathews	Data	flour and grist mill	8
	Six Mile Custom Mill	Six Mile	flour and grist mill	15
	Mayfield Bros.	Mertz	lumber and timber mill	29
†	Scottsville, Wool Carder	Scottsville	woolen goods	20
	J. M. Battle, (Six Mile Creek)	Six Mile	flour and grist mill.	50
	W. C. Trott, (Six Mile Creek)	Six Mile	cotton gin and grist mill	50
	W. H. Thomas, (Six Mile Creek)	Ashley	lumber and grist mill	35
	Dock Mahan, (Mahn's Creek)	Brierfield	wool carder and grist mill	40

*From U. S. Census, 1900.
†From report of Probate Judge.

NAME. POSTOFFICE. INDUSTRY.	H. P.
†Bessemer Land & Improvement Co. (Schultz Creek), Lopez, wool carder, grist mill and cotton gin	100
†R. R. McCally, (Hills Creek), Blocton, gin, lumber and grist	30
†E. M. Timbro, (Schultz Creek), Centerville, grist mill	30
†F. H. James, (Haysoppy Creek), Centerville, grist mill	20
†A. L. Elam, (Affonee Creek,) Affonee, grist mill	15

*BLOUNT COUNTY.

Logan Snead, Snead; flour and grist mill	10
E. B. Head, Gum Spring, flour and grist mill	16
E. R. Wood, Wynnville, flour and grist mill	8
Hendrick's Mill, Swansea, flour and grist mill	30
Jones M. Burns, Clarence, flour and grist mill	15
Wilson Adcock, Tidmore, flour and grist mill	10
G. M. D. Tidwell & Sons, Tidwell, flour and grist mill	20
Alldridge & Brother, Liberty, flour and grist mill	10
Brittain Mill, Summit, flour and grist mill	20
Morris' Mill, Ensley, flour and grist mill	10
Rufus F. Wyatt, Bangor, flour and grist mill	10
Sam Mardis, Blountsville, flour and grist mill	60
Jno. H. Donahoo & Geo. W. Darden, Rosa, lumber and timber	20

BULLOCK COUNTY.

Brooks' Mill, Mascotte, flour and grist mill	6
Union Springs Waste Mill, Union Springs, flour and grist mill	15
Chappell's Grist Mill, Union Springs, flour and grist mill	10
D. H. Mason, (McBride's Creek), Indian, lumber, gin and grist	20
From report of Probate Judge.	
†Chas. Radford, (Conecuh Creek), Union Springs, grist mill	10

*BUTLER COUNTY.

John W. Halso, Pigeon Creek, flour and grist mill	10
Glen Graham, Pontus, flour and grist mill	6
The Four Mile Mill, Greenville, flour and grist mill	10
The N. M. Rhodes Mill & Mercantile Co., Shell, flour, grist and lumber mill	50
Mrs. M. E. Crane, Monterey, flour and grist mill	15
Rouse & Whiddon, Greenville, flour and grist mill	50

CALHOUN COUNTY.

*Joseph Francis, Cane Creek, flour and grist mill	50
*Richey Mill, Jacksonville, flour and grist mill	20
*Canada Grist Mill, Womack, flour and grist mill	16
*Cold Water Mills, Cold Water, flour and grist mill	20
*Read's Mill, Reads, flour and grist mill	60
*Luther Barton, Piedmont, flour and grist mill	20
*W. F. McCulley, Oxford, flour and grist mill	20
*A. McCurdy, White Plains, flour and grist mill	34
*Morris Grist Mill, Morrisville, flour and grist mill	18
*Nisbet's Mill, Jacksonville, flour and grist mill	30
*James A. Weatherly, DeArmanville, flour and grist mill	8

*From U. S. Census, 1900.
†From report of Probate Judge.

	NAME. POSTOFFICE. INDUSTRY.	H. P.
	Wood Milling Co., Ohatchee, flour and grist mill	26
*	Davis & Henderson, Piedmont, flour and grist mill	24
	Hendon's Grist Mill, Iron City, flour and grist mill	10
	Hughes' Saw Mill, Oxford, lumber and timber mill	28
	F. M. Whiteside, (Choccolocco Creek), White Plains......25 or	30
	Downing & Morris, (Choccolocco Creek), Choccolocco	50
	J. T. DeArman, (Choccolocco Creek), Anniston	15
	W. E. Mellon, (Choccolocco Creek), Oxford	40
	Lee's Mill, (Choccolocco Creek), Oxford	30
	T. G. Slaughter, (Choccolocco Creek), Oxford	15
	J. H. Savage, (Terrapin Creek), Anniston	20
	J. H. Savage, (Terrapin Creek), Anniston	20
	Frank Aderhold, (Nances Creek), Ladiga	20
	John Ramagnand, (Champion Creek), Jacksonville	15
	James Crook, (Tallasseehatchee Creek), Jacksonville	10
	W. J. Edmondson, (Tallasseehatchee Creek), Anniston	30
	W. A. Prickett, (Tallasseehatchee Creek), Alexandria	10
	Beaty Estate, (Tallasseehatchee Creek), Alexandria	30
‡	Peter Heifner, (Tallasseehatchee Creek), Alexandria	15
	James Aderhold, (Ohatchee Creek), Reads	20
	Pleas. Martin, (Ohatchee Creek), Peekshill	25
	C. J. Wood, (Ohatchee Creek), Jacksonville	30
	Wm. Thompson, (Ohatchee Creek), Peekshill	8
	R. L. Treadway, (Tallasseehatchee Creek), Anniston, R. F. D	10
	J. H. Francis, (Tallasseehatchee Creek)	25
	R. H. Cobb, (Tallasseehatchee Creek), Anniston	20
	G. W. S. Loyd, (Cane Creek), Peaceburg	10
	Mrs. Loyd, (Cane Creek), Peaceburg, gin	6
	Morris Mfg. Co., (Cane Creek), Morrisville, shops	30
	E. G. Morris, (Cane Creek), Morrisville	30
	P. H. Brothers, (Cane Creek), Zula	30
	J. H. Francis, (Cane Creek)	50

*CHAMBERS COUNTY.

D. E. M. Smith, Barber, flour and grist mill	24
Cumbees Grist Mill, Stroud, flour and grist mill	20
Thomas H. Fuller, Lafayette, flour and grist mill	10
R. T. Humphrey, West Point, Ga., flour and grist mill	42
J. T. Hudson, Hickory Flat, flour and grist mill	4
Wyche Robinson, Lafayette, flour and grist mill	16
Stephens' Mill, Driver, flour and grist mill	8
Ripville Mills, Wise, flour and grist mill	20
Charles F. Higins, Finley, flour and grist mill	20
J. E. Dixon, Lafayette, flour and grist mill	10
Ratchford & Tucker, Lafayette, flour and grist mill	10
Benjamin F. Knight, Lafayette, flour and grist mill	10
Wooddy & Beall, Moorefield, flour and grist mill	6
Leverett's & Abernathy's Mill, Milltown, flour and grist mill	4
John B. Calhoun, Camphill, flour and grist mill	8
G. L. Leverett, Lafayette, flour and grist mill	16
West Point Mfg. Co., West Point, cotton goods	1,100

*From U. S. Census, 1900.
†From report of Probate Judge.
‡From report of L. J. Morris.

CHEROKEE COUNTY.

	NAME. POSTOFFICE. INDUSTRY.	H. P.
	Shamblin & Toles Mill, Broomtown, flour and grist mill......	8
	Chandler & Stinson, Center, flour and grist mill...............	20
	Shamblin & Toles Mill, Broomtown, flour and grist mill......	20
	J. A. Lumpkin, Forney, flour and grist mill..................	13
	Hurleys Mill, Hurley, flour and grist mill..................	12
*	Tyre G. Craig, Grover, flour and grist mill.................	12
	Rush Mill, Lawrence, flour and grist mill..................	10
	E. W. Ragdale, Spring Garden, flour and grist mill...........	30
	W. F. Timmerman, Round Mountain, flour and grist mill....	8
	M. E. Cohia, Cedar Bluff, flour and grist mill...............	24
	M. J. Abernathy, Pleasant Gap, lumber and timber mill......	15
	Hurricane Creek Mfg. & Min. Co., Spring Garden, cotton goods	65
	W. A. Stinson, (Terrapin Creek), Center, gin, flour and grist	60
	J. J. Scroggin, (Terrapin Creek), Coloma, gin, flour and grist	60
	T. F. Stewart, (Terrapin Creek), Spring Garden, flour and grist	60
	J. M. Adderhold, (Mill Creek), Piedmont, flour, grist and gin	40
	M. L. Braswell, (Hurricane Creek), Pleasant Gap, flour & grist	40
	B. F. Newberry, (Yellow Creek), Round Mountain, flour, grist, and gin mill	40
	E. Cobia, (Chattooga River), Cedar Bluff, flour, grist, and gin	60
†	R. A. Russell & Co. (Chattooga River), Gaylesville, flour, grist and gin mill	60
	W. F. Henderson, (Mill Creek), Fullerton, flour, grist and gin	40
	Rush & Rinehart, (Chattooga River), Fullerton, flour, grist, gin	60
	J. G. Toles, (Mill Creek), Broomtown, grist and gin mill....	40
	Elliott Bros., (North Spring Creek), Grassland, grist and gin	40
	J. T. Webb & Bros., (Spring Creek), Hurley, grist and gin mill	40
	J. D. Jordan, (South Spring Creek), Noah, grist and gin mill..	20

*CHILTON COUNTY.

James Dorming, Jemison, flour and grist mill...............	10
Mahan's Mill, Clanton, flour and grist mill..................	20
W. W. Sansome, Adams, flour and grist mill.................	12
Honeycutt Mill, Jemison, flour, grist, lumber and timber mill	20

*CHOCTAW COUNTY.

Pink Blackwell, Hinton, flour and grist mill.................	12
Aquilla Mills, Aquilla, lumber and timber mill...............	16

*CLARKE COUNTY.

Gate's Mill, Vashti, flour and grist mill.....................	30
Fleming's Grist Mill, Nealton, flour and grist mill............	10
Dacy's Mill, Whatley, flour and grist mill...................	5

*From U. S. Census, 1900.
†From report of Probate Judge.

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*CLAY COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
Henry F. Smedley, Mellow Valley, flour and grist mill	15
Hezakiah Ingram, Hatchett Creek, flour and grist mill	10
Allen P. Jenkins, Delta, flour and grist mill	14
Knight's Mill, Wesobulga, flour and grist mill	14
F. M. Munroe, Millerville, flour and grist mill	40
John R. Gilbert, Pinckneyville, flour and grist mill	8
Hodnett & Co., Hat, flour and grist mill	10
Moses R. Watts, Dean, flour and grist mill	6
Thomas J. Watts, Shinbone, flour and grist mill	8
Bishop, Carpenter & Co., Cherrry, flour and grist mill	10
Cockrell & Mitchell, Goldburg, flour and grist mill	14
McRairie, Gladney & Co., Cherry, flour and grist mill	20
Virginia Whellen, Coleta, flour and grist mill	6
Stephens & East, Delta, flour and grist mill	4
Deberry & Griffin, Flatrock, flour and grist mill	15
Child's Mill, Swann, flour and grist mill	5
James B. Brown, Pinckneyville, flour and grist mill	6
James J. Bachus. Fishhead, flour and grist mill	24
Brooks & Handley, Hatchett Creek, flour and grist mill	8
Columbus Bell, Lineville, lumber and timber mill	10
J. C. Kennedy, Fishhead, lumber and timber mill	14
William M. Patterson, Meadow, lumber and timber mill	30
Ward & Ford, Lineville, lumber and timber mill	15

*CLEBURNE COUNTY.

J. T. & E. W. Beason, Beasons Mill, flour and grist mill	10
W. M. Evans, Edwardsville, flour and grist mill	20
Robert Mill, Oaklevel, flour and grist mill	16
Teague & Co., Eudora, flour and grist mill	13
H. F. Alsabrook, Borden Springs, flour and grist mill	30
Buttram's Mill, Bucham, flour and grist mill	20
John A. Brown, Bell Mills, flour and grist mill	16
John I. Burgess, Edwardsville, flour and grist mill	20
Wade H. Barnes, Muscadine, flour and grist mill	4
J. W. Conner, Chulafinnee, flour and grist mill	6
Lyon & Killebrue, flour and grist mill	34
W. G. Miligan, Oakfuskee, flour and grist mill	8
James McMahan, Edwardsville, flour and grist mill	12
E. W. Pitchford, Oaklevel, flour and grist mill	15
William J. Thrash, Oakfuskee, flour and grist mill	6
Wade H. Barnes, Muscadine, flour and grist mill	30
W. H. Tumlin & D. S. Baber, Ai, flour and grist mill	16

*COFFEE COUNTY.

Levy Wise, Ino, flour and grist mill	5
Bell Mill, Dot, flour and grist mill	8
Lenora F. Hildreth, Enterprise, flour and grist mill	17
Harper Flour Mills, Brockton, flour and grist mill	4
F. M. Prestwood, Fresco, flour and grist mill	20
McIntosh Mill, Eta, flour and grist mill	8
Wise's Lower Mill, Elba, flour and grist mill	12
Wise's Upper Mill, Elba, flour and grist mill	10
Buck & Co., Penn, lumber and timber mill	50

*From U. S. Census, 1900.

*COLBERT COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
George Martin, Allsboro, flour and grist mill	8
James Burns, Mand, flour and grist mill	4
Tuscumbia Mill, Tuscumbia, flour anu grist mill	40
C. C. Hester, Tuscumbia, flour and grist mill	40
Chambee's Grist Mill, Tuscumbia, flour and grist mill	8
Dillard's Mills, Russellville, lumber and timber	12
Steenson's Mill, Sheffield, lumber and timber	30

*CONECUH COUNTY.

George Stenson, Bonnette, flour and grist mill	12
James B. Pate, Brooklyn, flour and grist mill	5
William M. Robinson, Brooklyn, flour and grist mill	5
Jimson C. Cox, Gem, flour and grist mill	5
John N. Varner & Chas. M. Varner, Herbert, flour and grist	10
James E. Wilson, Mount Union, flour and grist mill	20
Ransom H. Finley, Zern, flour and grist mill	8
G. G. Broker, Bowles, lumber and timber mill	10
Cary & Johnston, Brooklyn, lumber and timber mill	15
T. N. Piggott, Gravella, lumber and timber mill	40
Robinson Bros., Brooklyn, lumber and timber mill	30
H. J. Robinson, Burnt Corn, lumber and timber mill	40
Henry Wills, Finklet, lumber and timber mill	30

*COOSA COUNTY.

Miller's Mill, Bentleyville, flour and grist mill	20
Nolen's Mill, Darden, flour and grist mill	15
J. T. M. Hodnett & O. P. Hodnett, Equality, flour and grist mill	12
W. N. Neighbors, Goodwater, flour and grist mill	23
Smith's Mill, Nixburg, flour and grist mill	10
George P. Waits, Rockford, flour and grist mill	8
Crawford Mill, Rockford, flour and grist mill	4
Lawson Grist and Saw Mill, Rockford, lumber and timber mill	36

*COVINGTON COUNTY.

A. J. Fletcher, Andalusia, flour and grist mill	10
Uatu Grist Mill, Andalusia, flour and grist mill	10
William Sharp, Ealums, flour and grist mill	10
Davis B. Gantt, Gantt, flour and grist mill	12
C. E. Rawls, Gantt, flour and grist mill	10
Dorsey's Mill, Glasiasko, flour and grist mill	10
James Aplin, Green Bay, flour and grist mill	20
William Watkins, Liberty Hill, flour and grist mill	8
Kearsey's Mill, Redlevel, flour and grist mill	5
Ephram F. Lassiter, Rosehill, flour and grist mill	10
Thomas Saw Mill, Redlevel, lumber and timber mill	25
Simmons Mill, Beck, lumber and timber mill	40
J. A. Prestwood, Jr., Andalusia, lumber and timber mill	40
George W. Lee, Rat, lumber and timber mill	20
Buck Creek Mill, River Falls, lumber and timber	80
J. F. Guthrie, Vera Cruz, lumber and timber mill	25
Gunter's Mill, Andalusia, lumber and timber mill	40
Gunter's Saw Mill, Gantt, lumber and timber mill	15
Gantt's Mill, River Falls, lumber and timber mill	70
Pollard Gantt, Searight lumber and timber mill	35
Davis B. Gantt, Gantt, lumber and timber mill	40
N. B. Dixon, Mason, lumber and timber mill	60
Bartlett & Barker, lumber and timber mill	60

*From U. S. Census, 1900.

*CRENSHAW COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
E. P. Lasseter, Bullock, flour and grist mill	8
G. B. Morgan, Bullock, flour and grist mill	15
Folmar's Mill, Goshen, flour and grist mill	8
N. Skipper, Honoraville, flour and grist mill	10
Daniel & Co., Lapine, flour and grist mill	30
John S. Marsh, Rutledge, flour and grist mill	20
G. B. Sasser, Luverne, flour and grist mill	15

*CULLMAN COUNTY.

Joseph W. Hyatt, Baileyton, flour and grist mill	10
Miles Humphries, Baileyton, flour and grist mill	4
D. H. Laney, Battleground, flour and grist mill	6
Robert J. Waldrop, Cranehill, flour and grist mill	20
Andrew J. Miller, Summit, flour and grist mill	6

*DALE COUNTY.

Archer McCall, Candy, flour and grist mill	10
Floyd Mill, Dothan, flour and grist mill	10
Lewis Mill, Clopton, flour and grist mill	15
Murphy Mill, Dothan, flour and grist mill	5
Maunds Corn Mill, Ewells, flour and grist mill	10
Pope's Mill, Grimes, flour and grist mill	60
Charles Thrower, Kleg, flour and grist mill	16
Daniel McSwean, Ozark, flour and grist mill	20
Preston's Mill, Peach, flour and grist mill	20
The Kelley Grist Mill, Pinckard, flour and grist mill	150
Atkinson's Saw Mill, Newton, lumber and timber mill	16
J. F. Bell, Daleville, lumber and timber mill	22

*DALLAS COUNTY.

Calhoun's Mill, Carlowville, flour and grist mill	10
Ivey & Williams, Morrowville, flour and grist mill	8

DEKALB COUNTY.

*	L. D. Wooten, Blake, flour and grist mill	8
	J. D. Hall, Chavies, flour and grist mill	10
	J. S. Ward, Chumley, flour and grist mill	12
	Kean & Warren, Cordell, flour and grist mill	20
	Swindell's Mill, Cotnam, flour and grist mill	12
	Griffin's Mill, Cotnam, flour and grist mill	12
	Emeline Clayton, Crossville, flour and grist mill	6
	Swader's Mill, Dekalb, flour and grist mill	15
	James Clark, Eula, flour and grist mill	15
	David J. Harper, Floy, flour and grist mill	3
	Elrod's Grist Mill, Flay, flour and grist mill	4
	Davis Mill, Fort Payne, flour and grist mill	16
	Thomas F. Everett, Luna, flour and grist mill	8
	Elrod's Mill, Geraldine, flour and grist mill	30
	Pruitt's Mill, Skirum, flour and grist mill	12
	Lebanon Flour & Grist Mill, Lebanon, flour and grist mill	36
	Robert F. Ellison, Mentone, flour and grist mill	25
	Ellic Ellsworth, Opnir, flour and grist mill	6
	Warren's Grist Mill, Portersville, flour and grist mill	12

*From U. S. Census, 1900.

NAME. POSTOFFICE. INDUSTRY.	H. P.
John F. Williams, Rains, flour and grist mill	8
Edward W. Williams, Rains, flour and grist mill	6
McGee's Mill, Sand Rock, flour and grist mill	5
Charles G. Matheny, Sauty Mills, flour and grist mill	20
Dixie Mills, Sulphur Springs, flour and grist mill	10
* Phillips' Mill, Valleyhead, flour and grist mill	4
The Roberts Mill Co., Collinsville, flour and grist mill	25
W. E. Brown & Son, Sulphur Springs, lumber and timber mill	15
James M. Durham, Chavies, lumber and timber mill	16
William C. Hill & Co., Blanche, lumber and timber mill	40
D. D. Hughes, Hughes, lumber and timber mill	15
Ward, Pickens & Co., Dawson, lumber and timber mill	15
John A. Davis, (Wills Creek), Fort Payne, grist mill and gin	
M. S. Brown and W. C. Thomas, (Lookout Creek), Sulphur Springs, flouring mill	
† D. D. Hughes, (Wills Creek), Hughes P. O.; flour & grist mill	
P. M. Frazier, (Wills Creek), Lebanon, flour and grist mill	
S. D. Warren, (Wills Creek), Lebanon, flour and grist mill	
Grif. Elrod, (Town Creek), South Hill, flour and grist mill	
Durham & Co., (Town Creek), Chavies, flour, grist & saw mill	

*ELMORE COUNTY.

E. & H. T. Andrews, Channahatchee, flour and grist mill	25
Benjamin Spigener, Elmore, flour and grist mill	5
Sykes Mill, Sykes Mill, flour and grist mill	16
John C. Birt (Lancaster Old Mill,) Tallassee, flour and grist	24
Freeman's Grist Mill, Tallassee, flour and grist mill	5
J. J. Benson, Kowaliga, lumber and timber mill	20
J. T. Rogers, Spigners, lumber and timber mill	36
(From Chapter III.)	
‡Tallassee Falls Mfg. Co., (Tallapoosa River,) Tallassee, cotton and woolen goods	8,900
Montgomery Power Co. (Tallapoosa River), Tallassee, electric transmission to Montgomery, Ala.	5,600

*ESCAMBIA COUNTY.

Bradley Mill, flour and grist mill	10
S. S. Overstreet, Roberts, flour and grist mill	20
James F. Douglas, Mason, lumber and timber	25

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*From U. S. Census, 1900.

‡This is the same company that is now organized under the name of the Mt. Vernon Woodbury Cotton Duck Company, with office at Montgomery, Ala.

ETOWAH COUNTY.

	NAME. POSTOFFICE. INDUSTRY.	H. P.
	Wesson Mills, Attalla, flour and grist mill	25
	Cox & Brother, Avery, flour and grist mill	6
	B. H. Rogers, Etowahton, flour and grist mill	40
	T. G. Ewing, Ewings, flour and grist mill	60
	John C. Rollins, Fenton, flour and grist mill	8
	Reese Mill, Hill, flour and grist mill	10
	John H. Helms, Ballplay, flour and grist mill	6
	Ford & Sibert's Mill, Hokes Bluff, flour and grist mill	30
*	Morgan & Cochran, Keener, flour and grist mill	8
	W. J. Harris, Nix, flour and grist mill	12
	John B. Burns, Seaborn, flour and grist mill	8
	A. B. Stephens, Seaborn, flour and grist mill	8
	W. H. Cobb, Steels Depot, flour and grist mill	20
	P. C. Turner, Walnut Grove, flour and grist mill	30
	P. C. Turner, Walnut Grove, woolen goods	13
	W. M. Brothers & Son, Gallant, woolen goods	8
	Gadsden Times-News, Gadsden, printing and publishing	4
	J. M. Moragne, (Big Wills Creek), Gadsden, grist mill	100
	Wm. McClendon, (Big Wills Creek), Attalla, grist mill	40
†	— Griffith, (Big Wills Creek), Keener, grist mill	35
	Bob Rigers, (Big Canoe Creek), Gadsden, grist mill	75
	Tom Ewing, (Cane Creek), Gadsden, grist mill	40

FAYETTE COUNTY.

	Rodolphus Cotton, Bankston, flour and grist mill	20
	D. G. Hester, Covin, flour and grist mill	12
	John W. Anthony, Glenallen, flour and grist mill	30
*	Landon Miles, Hester, flour and grist mill	13
	Bishop Emick, Rena, lumber and timber mill	40
	Phillip N. Fortenberry, Bankston, lumber and timber mill	8
	W. L. Caine, (Sipsey River), Fayette, saw and grist mill	40
	T. E. Newton & Bro., (Sispey River), Fayette, saw and grist	40
	Licurgas Ray, (Luxapelila Creek), Montcalm, saw and grist..	30
	John Barnes, (Luxapelila Creek), Covin, gin and grist mill..	30
	E. Bishop, (Luxapelila Creek), Rainy, saw, gin and grist mill	30
	John Williams, (Luxapelila Creek), Covin, gin and grist mill..	30
	Washington Hubbert, (Shirley Creek), gin and grist mill	10
	Gilpin & Jones, (Shirley Creek), saw, gin and grist mill	16
	Jones & Jones, (Shirley Creek), Hugent, saw, gin & grist mill	20
	P. N. Fortenberry, (Davis Creek, Bankston, saw, gin and grist	8
	G. H. White, (Davis Creek), Davis Creek, saw, gin and grist	16
†	J. W. Blackburn, (Davis Creek), Davis Creek, saw, gin & grist	18
	M. I. Barnette, (Davis Creek), Ridge, saw, gin and grist mill..	20
	Dolphus Cotton, (Clear Creek), Bankston, saw, gin and grist	16
	M. Miller, (Clear Creek), Bankston, saw, gin and grist mill..	
	John G. Kizer, (North River), Berry Station, saw, gin & grist	40
	Marshall Jones, (Bear Creek), Bear, saw, gin and grist mill	20
	R. G. Walker, (Bear Creek), Bear, saw, gin and grist mill	24
	Landon Miles, (Stewart Creek), Hester, grist mill	12
	J. T. McCaleb, (Mountain Creek), New River, grist mill	16
	W. A. Ayers, (Beaver Creek), Fayette, gin and grist mill	12
	G. W. Gray, (Boxes Creek), Stough, grist mill	16
	Miles Whitson, (Clear Creek), Handy, grist mill	12
	Bud Wade, (Hollingsworth Creek), New River, grist mill	12

*From U. S. Census, 1900.
†From report of Probate Judge.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
***FRANKLIN COUNTY.**			
Helm's Mill	Belgreen	flour and grist mill	6
M. J. Height	Baggett	flour and grist mill	10
James McNair	Kirby	flour and grist mill	20
Andrew Posey	Igoburg	flour and grist mill	24
Thomas Watson	Phil Campbell	flour and grist mill	20
S. T. Bonds	Pleasant Site	flour and grist mill	80
Jes. S. Scott	Russellville	flour and grist mill	10
Sparks Mill	Underwood	flour and grist mill	10
John T. McAlister	Phil Campbell	lumber and timber mill	10
***GENEVA COUNTY.**			
Avant's Mill	Geneva	flour and grist mill	15
Lowry's Mill	Geneva	flour and grist mill	10
Bell's Mill	Fadette	flour and grist mill	15
W. J. Keith and R. Y. Daniels	Geneva	flour and grist mill	15
Clark's Grist Mill	Highnote	flour and grist mill	4
Underwood's Grist Mill	Sanders	flour and grist mill	20
Condry's Grist Mill	Whitaker	flour and grist mill	15
John T. Coleman	Geneva	lumber and timber mill	30
Clark Bros. & Co.	Wicksburg	lumber and timber mill	10
Wilson Deshoga	Dundee	lumber and timber	15
Nathan Hall	Dotham	lumber and timber	20
HALE COUNTY.			
* William Steward	Fivemile	flour and grist mill	8
William A. Avery, (Five-Mile Creek)	Five-Mile	flour and grist	10
J. H. Payne & Co.	Ingram	flour and grist mill	10
M. M. Avery	Havanna	flour and grist mill	15
Pickens Mill	Greensboro	lumber and timber mill	15
Greensboro Carriage & Wagon Shops	Greensboro	carriages and wagons	6
‡ Richardsons Mills, (Five-Mile Creek)	Five-Mile	grist mill and gin	20
J. H. Payne's Mill, (Five-Mile Creek)	Havana	grist and gin	20
Avery's Mill, (Five-Mile Creek)	Havana	grist mill and gin	25
J. A. Stephenson, (Prairie Creek)	Newbern	grist mill & gin	20
Irwin & Martin, (Big Creek)	Greensboro	grist mill and gin	25
***HENRY COUNTY.**			
Kennedy's Mill	Shorterville	flour and grist mill	8
Joshua A. Hart	Granger	flour and grist mill	15
Jeffcoat Mill	Gordon	flour and grist mill	8
Blacksheer & Saunders	Haleburg	flour and grist mill	25
Cumming's Mill	Bush	flour and grist mill	20
Joe Baker	Hadland	flour and grist mill	27
Badiford Grist Mill	Little Rock	flour and grist mill	15
Blackshe & Sanders	Haleburg	flour and grist mill	15
John L. Smith	Ashford	flour and grist mill	13
Mark Shelley	Balkum	flour and grist mill	6
Singleterry's Water Mill	Kinsey	lumber and timber	27
J. P. Williams & Co.	Columbia	lumber and timber	25

*From U. S. Census, 1900.
†From report of Probate Judge.

*JACKSON COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
Moody's Flouring Mill, Kyles, flour and grist mill	40
George W. Brown, Kosh, flour and grist mill	8
J. F. Bell, Maxwell, flour and grist mill	4
Coffey's Mill, Scottsboro, flour and grist mill	8
Gross Mill, Parks Store, flour and grist mill	10
Hackworth's Mills, Bolivar, flour and grist mill	8
John S. Henegar, Rosalie, flour and grist mill	20
Bort Harrison, Section, flour and grist mill	6
W. A. Howell, Hollytree, flour and grist mill	5
Mathew's Grist Mill, Carns, flour and grist mill	10
Page's Mill, Woodville, flour and grist mill	6
Paint Rock Milling Co., Paint Rock, flour and grist mill	8
Reid & Prince, Estillfork, flour and grist mill	20
David H. Starkey, Kosh, flour and grist mill	8
Shork Mills, Hollywood, flour and grist mill	60
Cagle Mill, Oakley, flour and grist mill	12
John Thomas, Pisgah, flour and grist mill	20
Martin Walker, Trenton, flour and grist mill	40
James P. Williams, Trenton, flour and grist mill	20
John V. Wheeler, Pisgah, flour and grist mill	20
Charles W. Brown, Glenzaida, lumber and timber mill	25
J. N. Gonce, Anderson, lumber and timber mill	20
Melton Morris, Daugherty, lumber and timber mill	12
David M. Starkey, Kosh, lumber and timber mill	20
Tomon Shingle Mill, Culver, lumber and timber mill	10

*JEFFERSON C6OUNTY.

J. M. Landrum, Pinson, flour and grist mill	20
John Lowery Mill, Gary, flour and grist mill	12
Hendon's Corn Mill, Trussville, flour and grist mill	10
Posey's Mill, Morris, flour and grist mill	20
James W. Raney, Ezra, flour and grist mill	35
William B. Rogers, Toadvine, flour and grist mill	32
G. W. Underwood, Argo, flour and grist mill	15
William J. Wedgworth, Cardiff, flour and grist mill	10
W. W. Woodruff, Adamsville, flour and grist mill	8
W. M. Self, Oneonto, flour and grist mill	15
William M. Phillip, Greene, flour and grist mill	40
Hurst & Johnson, Pinson, lumber and timber mill	18
James W. Raney, Ezra, woolen goods	35

LAMAR COUNTY.

* John H. Cantrell, Pharos, flour and grist mill	15
Claborn E. Carter, Detroit, flour and grist mill	12
Kirk's Mill, (Yellow Creek), Sizemore, flour and grist mill	8
Mote's Mill, (Beaver Creek), Guin, flour and grist mill	6
John T. Moore, (Yellow Creek), Vernon, flour and grist mill	35
H. W. Miller, (Luxapelila Creek), Millport, flour and grist mill	20
Stanford Mills, Detroit, flour and grist mills	12
S. B. Thomas, Arcola, flour and grist mills	10
Lafayette J. Hayes, Molloy, lumber and timber mill	15
Hiram Hollis, Vernon, lumber and timber mill	35
Dr. Wm. H. Kennedy, Kennedy, lumber and timber mill	50
S. B. Thomas, Arcola, lumber and timber mill	15

*From U. S. Census, 1900.

	NAME. POSTOFFICE. INDUSTRY.	H. P.
	J. O. Kennedy, Kennedy, mill and gin	
	J. W. Thomas, Jr.. (Hills Creek), Alfred, gin, saw and grist	
	W. M. Thomas, (Hills Creek), Alfred, gin, saw and grist mill	
	Osborn & Hill, (Yellow Creek), Blowhorn, gin, saw and grist	
†	D. M. Hollis, (Beaver Creek), Beaverton, gin, saw and grist	
	B. G. Boman, (Yellow Creek), Vernon, gin, saw and grist mill	
	A. A. Mathews, (Yellow Creek), Arcola, gin, saw and grist mill	
	W. L. Morton, (Yellow Creek), Vernon, gin, saw and grist mill	
	Penning Bros., Baxter, gin, saw and grist mill	

*LAUDERDALE COUNTY.

	William M. Thornton, Rogersville, flour an grist mill	20
	James A. Bevis, Threet, flour and grist mill	8
	Jessie J. Bevis, Kendell, flour and grist mill	6
	George M. Bretherick, Hines, flour and grist mill	24
	Isa B. Eastep, Eastep, flour and grist mill	8
	Ingram Brothers, Anderson, flour and grist mill	8
	Thomas D. Pruitt, Pruitton, flour and grist mill	24
	Sharpe's Mill, Florence, flour and grist mill	40
	Nancy Williams, Lexington, flour and grist mill	20
	H. N. Call, Reserve, flour and grist mill	18
	Chandler & Chittam, Oliver, flour and grist mill	20

LAWRENCE COUNTY.

	Burrell & Casteel, Progress, flour and grist mill	10
	George's Mill, Leighton, flour and grist mill	18
	Jones' Estate, Kinlock, flour and grist mill	10
	Kerby's Mill, Avoca, flour and grist mill	16
*	Thomas Oliver, Hatton, flour and grist mill	16
	John S .Stephenson & Co., Kinlock, flour and grist mill	27
	Wesley L. Stover, Crow, flour and grist mill	15
	Terry & Terry, Courtland, flour and grist mill	20
	Wallace Mill, Avoca, flour and grist mill	10
	W. M. Willingham, Camp Spring, lumber and timber mill	1
	H. C. McClannaher, (Town Creek), Mount Hope, grist mill	
	John S. Stephenson, (Sipsey River,) Moulton, flour and grist	
	Ben F. Masterson, (Big Nance Creek), Moulton, grist mill	
†	W. G. Hamilton, (Big Nance Creek), Pitt, grist mill	
	J. M. Key, (Brushey Creek), Pool, grist mill	
	W. L. Stover, (Flint Creek), Oakville, flour and grist mill	
	B. A. Casteel, (Flint Creek), Sewickley, flour and grist mill	

LEE COUNTY.

	Shelton's Mill, Opelika, flour and grist mill	40
	Floyd Mill, Opelika, flour and grist mill	10
	George W. McKinnon, Yale, flour and grist mill	24
	Vaugh Mill, Loachapoka, flour and grist mill	20
*	N. G. Macon, (Reed Creek), Loachapoka, flour and grist mill	30
	W. O. Moore, Auburn, flour and grist mill	40
	W. K. Meadows, (Halawochee Cr.), Hattie, flour and grist mill	36
	James Crosby, Osanippa, flour and grist mill	15
	Benjamin F. Stripling, Yale, lumber and timber	20
	W. W. Wright, (Chewacla Creek), Auburn, not in use now	
	W. W. Wright & Geo. P. Harrison, Opelika, (Saugahatchee Cr.)	
†	H. J. Spratling, (Frazer Creek), Opelika, grist mill	25
	B. F. Meadows, (Halawochee Creek), Opelika, grist mill	40

*From U. S. Census, 1900.
†From report of Probate Judge.

LIMESTONE COUNTY.

	NAME. POSTOFFICE. INDUSTRY.	H. P.
	Weatherford Bros., Elkmont, flour and grist mill	6
	Carter's Mill, Athens, flour and grist mill	16
	Dupree & Stepp, Mount Rozell, flour and grist mill	25
	Haye's Grist Mill, Mooresville, flour and grist mill	15
	T. M. Holmes, Elkmont, flour and girst mill	12
	John M. Head, Pettusville, flour and grist mill	8
	Nancy Haney, Legg, flour and grist mill	20
	Edward G. Hampleton, Goodsprings, flour and grist mill	15
	Thomas D. Hastings, Elkmont, flour and grist mill	5
	James L. Lamar, Goodsprings, flour and grist mill	8
	Eugene Parham, (Piney Creek), Athens, flour and grist mill	8
*	M. A. Phillips, Shoalford, flour and grist mill	12
	Ripley's Mill, Ripley, flour and grist mill	15
	George Vassar, Lax, flour and grist mill	8
	Witty's Mill, (Birds Branch), Athens, flour and grist mill	15
	William J. Woodfin, Pettusville, flour and grist mill	15
	Pioneer Mill, Mount Rozell, flour and grist mill	20
	A. P. Andrews, Elkmont, flour and grist mill	8
	William N. Webb, Elkriver Mills, flour and grist mill	12
	Baker's Mills, Elkriver Mills, flour and grist mill	8
	Allison Miller, Rowland, flour and grist mill	10
	Grisham Bros., Elkriver Mills, lumber and timber	40
	Grisham Bros., Elkriver Mills, carriages and wagons	40
	L. C. Hightower, (Big Creek), Elkriver Mills, saw, flour and grist mill	
	Wm. Bailey, (Big Creek), Quidnunc, flour and grist mill	
	J. W. Carter, (Big Creek), O'Neal, gin, flour and grist mill	
	M. J. Witty, (Birds Branch), Athens, flour and grist mill	
	J. C. Vaughn, (Sulphur Creek), Elkmont, gin, flour & grist mill	
	R. B. Malone, (Sulphur Creek), Athens, gin, flour and grist mill	
†	Wm. Woodfin, (Ragsdale Creek), Elkmont, gin, flour and grist	
	J. W. Carter, (Panther Creek), Carter, gin, flour and grist mill	
	John Carroll, (Leslie Creek), Centerhill, gin, flour and grist mill	
	Wm. Davidson, (Limestone Creek), Lax, gin, flour and grist mill	
	R. M. Clem, (Piney Creek), Fairmount, gin, flour and grist mill	
	Eugene Parkam, (Piney Creek), Athens, gin, flour and grist mill	
	W. M. Hayes, (Limestone Cr.), Mooresville, gin, flour and grist	
	W. H. Roberts, (Sugar Creek), Athens, gin, flour and grist mill	
	W. H. Marbut, Goodsprings, gin, flour and grist mill	

LOWNDES COUNTY.

*G. B. Holley, Lowndesboro, flour and grist mill	10
†W. N. Bozeman, Benton, gin and mill	

*MADISON COUNTY.

Fannie J. Ridley, Haden, flour and grist mill	8
D. L. Middleton Water Mill, Gurley, flour and grist mill	20
Delop's Mill, Dan, flour and grist mill	8
Hardy Keel Water Mill, Gurley, flour and grist mill	15
Annie M. Taylor, Hazelgreen, flour and grist mill	8
Bellfactory Mill, Huntsville, flour and grist mill	25
Key's Mill, Keysmill, flour and grist mill	28
William S. Russell, Madison Station, flour and grist mill	12
Chas. F. Rountree, Maysville, flour and grist mill	15
William S. Garvin, Monrovia, flour and grist mill	15
A. D. and W. E. Rogers, Newmarket, flour and grist mill	60
Butler Mill Co., Poplarridge, flour and grist mill	30
Payne & Miller, Huntsville, flour and grist mill	30
Martin's Grist Mill, Huntsville, flour and grist mill	15
H. C. Turner, Dan, lumber and timber	16
Daily Mercury, Huntsville, printing and publishing	6

*From U. S. Census, 1900.
†From report of Probate Judge.

*MACON COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
H. H. Robinson, Loachapoka, flour and grist mill	4
M. W. Glass, Societyhill, flour and grist mill	8
J. O. H. Perry, Tuskegee, flour and grist mill	20

MARION COUNTY.

		H. P.
	The Carter Mill, Ur, nour and grist mill	5
	Bexar Mercantile Co., Bexar, flour and grist mill	8
	Eads & Fowler, Glenallen, flour and grist mill	12
	The Boatwright Mill, Inez, flour and grist mill	12
	Samuel A. & Wm. V. Read, Eldridge, flour and grist mill	20
	Jasper N. Green & Sons, Brilliant, flour and grist mill	20
	Elishu Vickery, Winfield, flour and grist mill	16
*	The Shirley Mill, Ur, flour and grist mill	10
	Jesse G. Poe, Bearcreek, flour and grist mill	6
	Bull, Atkins & Donaldson, Haleysville, flour and grist mill	52
	Buttahatchee Mill Co., Haleysville, lumber and timber	52
	John Cumens, Haleysville, lumber and timber	12
	Kelly Saw Mill, Haleysville, lumber and timber	15
	John R. Phillips, Bearcreek, lumber and timber	50
	Simon W. Moss, Winfield, lumber and timber	36
	The Powell Mill & Wool Carder, Duffey, woolen goods	50
	Albert J. Hamilton, (Williams Creek), Hamilton, flour and grist	
	W. C. Gann, (Sipsey Creek), Bexar, flour and grist mill	
	Q. Northington, (Sipsey Creek), Hamilton, flour and grist mill	
	Crane & Riggs, (Sipsey Creek), Delhi, flour and grist mill	
	T. L. Shotts, (Bull Mountain Creek), Shottsville, flour and grist	
	I. J. Loyd, (Bull Mountain Creek), Bull Mountain, flour and grist	
	D. F. Ballard, (Williams Creek), Hamilton, flour and grist mill	
†	James P. Pearce, (Buttahatchee River), Pearce's Mill, flour and grist mill	
	James P. Pearce, (New River), Texas, flour and grist mill	
	J. C. Carter, (Woods Creek), Elmira, flour and grist mill	
	James Young, (Cantrell Mill Creek), Hamilton, flour and grist	
	W. J. Wright, (Barnesville Mill Creek), Barnesville, flour and grist mill	
	Henry Guin, Guin, flour and grist mill	
	Tucker Moss, (Luxapelila Creek), Winfield, flour and grist mill	
	D. G. Morrow, (Woods Creek), Elmira, flour and grist mill	

*MARSHALL COUNTY.

	H. P.
J. M. Ellison, Preston, flour and grist mill	4
Mathis Mill, Albertville, flour and grist mill	10
James B. Powell, Columbus City, flour and grist mill	4
James F. Prentice, Arab, flour and grist mill	7
P. C. Ragsdale, Uniongrove, flour and grist mill	10
James P. Smith, Warrenton, flour and grist mill	10
Scott's Mill, Friendship, flour and grist mill	8
John D. Sumers, Boaz, flour and grist mill	15
Lakey Mill, Bartlett, flour and grist mill	10
George E. Whisnant & Son, Oleander, flour and grist mill	10
I. G. Gross, Columbus City, flour and grist mill	12
Walker & Fowler Mills, Friendship, flour and grist mill	20
William J. Copelan, Diamond, flour and grist mill	5
James Wm. Barclay, Woodville, flour and grist mill	10
The Winston Mill, Meltonsville, flour and grist mill	12
W. G. Smith Estate, Sidney, flour and grist mill	10
Jas. M. Selvage, Grant, flour and grist mill	4

*From U. S. Census, 1900.
†From report of Probate Judge.

MARENGO COUNTY

NAME. POSTOFFICE. INDUSTRY.	H. P.
*Rhodes Mill, Sweetwater, flour and grist mill	12

*MOBILE COUNTY.

N. Q. Thompson, Citronelle, flour and grist mill	10
H. Brannan & Son, Pierce, lumber and timber	30
T. A. Hatter & Son, Creola, lumber and timber	75
Littleton Lee, Pierce, lumber and timber	60

*MONROE COUNTY.

J. B. Solomon, Manistree, flour and grist mill	15
James H. Simpson, Mexia, flour and grist mill	10
Benjamin Johnson, Hollinger, flour and grist mill	15
Andrew Bohanon, Franklin, flour and grist mill	15
David J. Hatter & Son,, Wait, lumber and timber	60
David J. Hatter & Son, Wait, lumber and timber	20
C. C. Yarbrough, Monroeville, lumber and timber	20

*MONTGOMERY COUNTY.

Daniel's Mill, Sellers, flour and grist mill	25
Montgomery Cotton Mill, Montgomery, cotton goods	35

MORGAN COUNTY.

*Sarah M. McCutcheon, Briscoe, flour and grist mill	10

PERRY COUNTY.

*	Henry C. Nichols, (Dobynes Creek), Theo, flour and grist mill.	20
*	Mary G. Wallace, Marion, flour and grist mill	4
*	Hodger's Mill, Newbern, flour and grist mill	15
*	W. F. Moore, Marion, flour and grist mill	4
*	Downey's Saw Mill, Greensboro, lumber and timber	15
*	Stevenson's Saw & Water Mills, Newbern, lumber and timber.	20
*	Lucindy Washburn, (Taylor Creek), Jericho, lumber and timber	18
†	W. T. Downey, (Limestone Creek), Folsom, grist mill	6
†	James Wallace, (Legroane Creek), Jericho, grist mill	8
†	Dr. J. B. Tucker, (Taylors Creek), Jericho, grist mill	6
†	Lucindy Washburn, (Taylors Creek), Jericho, grist mill	8
†	S. M. Bolling, (Branch of Oakmulgee Cr.), Pinetucky, grist mill	8
†	C. C. Cosby, (Oakmulgee Creek), Perryville, grist mill	8
†	Thomas J. Fountain, (Little Creek), Oakmulgee, gin, saw and grist mill	8
†	Pann Patterson, (Little Creek), Oakmulgee, gin, saw and grist	8
†	Sarah Fountain, (Little Creek), Oakmulgee, gin, saw and grist	8
†	Thaddeus Smith, (Little Creek), Active, grist mill	8
†	W. M. Eiland, (Fords Mill Creek), Marion, grist mill	20
†	J. F. Morton, (Potato Patch Creek), Levert, grist mill	6
†	Elijah Smith, (Beaver Creek), Bliss, grist mill	6
†	Noah Coker, (Beaver Dam Creek), Bethlehem, grist mill	6
†	W. A. Fountain, (Oakmulgee Creek), Oakmulgee, rice mill	10

*PICKENS COUNTY.

Richardson & Prichards, Coalfire, flour and grist mill	25
James Mullenix, Gordo, flour and grist mill	6
H. B. & A. W. Latham, Carrollton, flour and grist mill	12
Slaughter's Mill, Raleigh, flour and grist mill	16
W. A. Kerr, Reform, lumber and timber	10

*From U. S. Census, 1900.
†From report of Probate Judge.

*PIKE COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
M. J. Youngblood, Youngblood, flour and grist mill	110
William F. Ingram, Josie, flour and grist mill	20
Nancy Cotton, (Cotton's Mill), Milo, flour and grist mill	12
Ely Dees & J. D. Murphee, Pronto, flour and grist mill	20
George W. King, Gosnen, flour and grist mill	30
The Lewis Mill, Rodney, flour and grist mill	24
McQuaggis Mill, Ansley, flour and grist mill	15
George F. Williams, Tatum, flour and grist mill	4
Slatting's Grist Mill, Henderson, flour and grist mill	25
P. A. Motia, Wingard, flour and grist mill	8
Bowden & Daughtry, Tennille, flour and grist mill	16
William E. Brown, Josie, flour and grist mill	10
G. B. Howard, Goshen, flour and grist mill	20

*RANDOLPH COUNTY.

W. W. Dobson, Wedowee, flour and grist mill	20
J. H. White & Z. N. Lipham, Clack, flour and grist mill	11
Mrs. Georgia Gibbs, Wedowee, flour and grist mill	10
Gilis Mill, Ofelia, flour and grist mill	10
Eppie M. White, Bernice, flour and grist mill	5
Larkin & M. B. Taylor, Lamar, flour and grist mill	8
Joseph B. Taylor, Roanoke, flour and grist mill	24
Owins Mill, Potash, flour and grist mill	15
Rogers Mill, Ofelia, flour and grist mill	8
C. A. Prescott, Wedowee, flour and grist mill	20
H. A. Merrill, Lamar, flour and grist mill	6
Elizabeth H. Merrill, Micaville, flour and grist mill	12
J. E. McCosh & Co., Lime, flour and grist mill	40
William S. McCarley, Graham, flour and grist mill	20
John H. Landers, Lofty, flour and grist mill	8
Edward Lavoorn, ———, flour and grist mill	8
Thomas J. Lavoorn, Hawk, flour and grist mill	16
Thomas J. Lavoorn, Sr., Newell, flour and grist mill	8
James L. & John T. Kaylor, Kaylor, flour and grist mill	60
Henry C. Jordon, Clack, flour and grist mill	6
J. B. Hammond, Sewell, flour and grist mill	8
T. M. Halaway, Tolbut, flour and grist mill	15
Robert H. Harris, Louina, flour and grist mill	15
Dock Huckaby, Almond, flour and grist mill	10
Holley's Mill, Rock Mills, flour and grist mill	30
E. C. Heaton, Hawk, flour and grist mill	10
William N. Gladney, Roanoke, flour and grist mill	12
A. B. East, Christiana, flour and grist mill	2
Adamson & Edward's Mills, Ofelia, flour and grist mill	25
Bailey Mill, Haywood, flour and grist mill	12
F. P. Parker, Foresters Chapel, flour and grist mill	10
John C. Murphy, Gay, flour and grist mill	2
E. L. Pool, Happyland, flour and grist mill	20
James M. Kitchens, Rockdale, flour and grist mill	8
James H. Wright, Jeptha, flour and grist mill	12
Adamson & Edwards, Ofelia, lumber and timber	40
William W. Brooks, Lofty, lumber and timber	15
William A. Camp, Almond, lumber and timber	10
James L. & John T. Kaylor, Kaylor, lumber and timber	20
H. H. Stephens, Pencil, lumber and timber	20
Samuel H. Striplin, Roanoke, leather, tanned, curried & finished	6
Wehadkee Cotton Mills, Rock Mills, cotton goods	108

*From U. S. Census, 1900.

RUSSELL COUNTY.

NAME. POSTOFFICE. INDUSTRY.	H. P.
* Davis' Mill, Crawford, flour and grist mill	20
* H. R. Dudley, Seale, lumber and timber	40
†E. M. Anderson, (Watermelon Cr.), Seale, grist mill and gin	20

*SHELBY COUNTY.

W. C. Denson, Pelham, flour and grist mill	12
William H. Shrader, Shelby, flour and grist mill	20
William H. Pledger, Pelham, flour and grist mill	40
Hendrick & Alverson, Vincent, flour and grist mill	40
David A. Whitfield, Vandiver, flour and grist mill	10
Brownings Mill, Columbiana, lumber and timber	30

*ST. CLAIR COUNTY.

The Yarbrough Mill, Ashville, flour and grist mill	8
Hare's Mill, Ashville, flour and grist mill	8
John R. Dyke, Wolfcreek, flour and grist mill	30
Perry E. Wyatt, Coal City, flour and grist mill	10
Henry A. Palmer, Partlow, flour and grist mill	10
J. M. McLaughlin, Springville, flour and grist mill	25
The Machen Mill, Partlow, flour and grist mill	10
The Lindsey Mill, Ashville, flour and grist mill	10
Hill & Foreman, Springville, flour and grist mill	28
Henderson's Mill, Ragland, flour and grist mill	5
Helm & Truss, Helms, flour and grist mill	20
Grout's Mills, Wolfcreek, flour and grist mill	10
The Gilchrist Mill, Ashville, flour and grist mill	5
The Cox Mill, Ashville, flour and grist mill	10
Rufus W. Beason, Whitney, flour and grist mill	11
Rock Bridge Mill, Gallant, lumber and timber mill	20

*SUMTER COUNTY.

E. B. Hearn, (Kinterbish Creek), Gaston,	40
R. H. Stephens, (Kinterbish Creek), Alamuchee	20
R. D. Simmons, (Toomsooba Creek), Bell's Station	30
R. W. Shaw, Cuba	10
W. H. Walker, (Silver Creek), Alamuchee	20
J. U. Gillespie, (Coatopa Creek), Coatopa	10

TALLADEGA COUNTY.

* Jefferson Roberson, Fayetteville, flour and grist mill	10
J. C. Brock, Eastaboga, flour and grist mill	12
Riser & Bro., Talladega, flour and grist mill	40
Shock E. Jemison, Sunnyside, flour and grist mill	15
Vincent Mill, Talladega, flour and grist mill	25
O. F. Luttrell, Talladega, flour and grist mill	40
Riddle Mills, Waldo, flour and grist mill	16
J. F. Smith, Eastaboga, flour and grist mill	40
John W. Thweatt, McFall, flour and grist mill	12
J. B. Turner, McFall, flour and grist mill	15
Allison's Mill, Talladega, flour and grist mill	60
J. F. Smith, Eastaboga, lumber and timber	40
Cragdale Mill, Talladega, lumber and timber	40
J. B. Turner, McFall, lumber and timber	20

*From U. S. Census, 1900.
†From report of Probate Judge.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
Priebes Mill, (Choccolocco Creek)	Jenifer	grist mill	200
J. F. Smith's Mill, (Choccolocco Creek)	Oxford	grist mill	225
B. Schmidt's Mill, (Choccolocco Creek)	Lincoln	grist mill	200
Craig's Mill, (Choccolocco Creek)	Oxford	grist mill	150
Wilson's Mill, (Choccolocco Creek)	Jenifer	grist mill	150
Eureka Mills, (Choccolocco Creek)	Eureka	grist mill	150
Turner's Mill, (Chehawhaw Creek)	McFall	grist mill	150
Kants Mill, (Talladega Creek)	Chandler Springs	grist mill	50
Riddle's Mill, (Talladega Creek)	Waldo	grist mill	75
Taylor's Mill, (Talladega Creek)	Talladega	grist mill	150
† Reynold's Mill, (Talladega Creek)	Nottingham	grist mill	150
Allison's Mill, (Talladega Creek)	Talladega	grist mill	75
Duncan's Mill, (Talladega Creek)	Alpine	grist mill	75
Baker's Mill, (Talladega Creek)	Kymulga	grist mill	100
Vincent's Mill, (Crooked Creek)	Sylacauga	grist mill	50
Oden's Mill, (Short Creek)	Sylacauga	grist mill	75
Jemison's Mill, (Kelley's Creek)	Sunnyside	grist mill	50
Camp & Sons' Mill, (Salt Creek)	Hopeful	grist mill	50
Robinson's Mill, (Cedar Creek)	Fayetteville	grist mill	50
Lackey's Mill, (Horse Creek)	Ironaton	grist mill	25
Talladega Company, (Choccolocco Creek)	Talladega	organized for electric transmission	

*TALLAPOOSA COUNTY.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
George Stewart	Thaddeus	flour and grist mill	12
John W. Britt	Jacksons Gap	flour and grist mill	20
Benjamin F. Jarvis	Yates	flour and grist mill	12
T. J. Hamlet	Hamlet	flour and grist mill	15
T. W. Whitman	Dadeville	flour and grist mill	20
Sanford Milling & Mfg. Co.	Dadeville	flour and grist mill	25
John W. Hay	Camphill	flour and grist mill	15
Hammond's Mill	Dadeville	flour and grist mill	20
Hodnett Grist & Flour Mill	Acme	flour and grist mill	16
Thomas L. Bulger	Dadeville	flour and grist mill	15
Vines Mills	Easton	flour and grist mill	40
A. T. & H. C. Vickers	Newsite	flour and grist mill	20
J. C. Street	Anniston	flour and grist mill	25
Shephard Bros. & Co.	Tohopeka	flour and grist mill	10
G. W. Stewart	Thaddeus	flour and grist mill	25
Albert J. Hollaway	Alexander City	flour and grist mill	20
Mrs. Milliner	Mary	flour and grist mill	25
Jno. L. Patterson	Hackneyville	flour and grist mill	12
Thomas B. Griffin	Matilda	flour and grist mill	10
Daviston Mill	Daviston	flour and grist mill	8
Lamberth & Dewberry	Logpit	flour and grist mill	20
Silver Shoals Mill	Buttston	flour and grist mill	80
M. R. Hays & Bro.	Notasulga	flour and grist mill	40
Farrows Flour & Grist Mill	Susanna	flour and grist mill	60
J. H. Yarbrough	Hackneyville	flour and grist mill	12
T. F. Garnett	Tallassee	lumber and timber	20
G. W. Stewart	Thaddeus	lumber and timber	20

*From U. S. Census, 1900.

†From report of Probate Judge.

*TUSCALOOSA COUNTY.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
Price's Mill	Binion	flour and grist mill	8
Keene's Mill	Cottondale	flour and grist mill	20
B. E. Thompson	Cottondale	flour and grist mill	15
Wm. D. Shadix, (Sandy Creek)	Double Springs	flour and grist	4
J. W. Spencer	Elrod	flour and grist mill	10
Webb's Mill	Elrod	flour and grist mill	20
Hagler's Mill	Falls	flour and grist mill	40
Patton's Mill	Fosters	flour and grist mill	12
David M. Montgomery	Moores Bridge	flour and grist mill	10
Looney John Mills	New Lexington	flour and grist mill	6
Eitson's Mill	New Lexington	flour and grist mill	12
Alfred Gilliland	Newtonvile	flour and grist mill	12
Andrew J. Hewett	Skelton	flour and grist mill	5
Tierce's Mill	Tierce	flour and grist mill	10
James M. Yerby	Tuscaloosa	flour and grist mill	20
O. W. Glenn	Tyner	flour and grist mill	8
The Rope & Yarn Mills, (Binion's Creek)	Samantha	cordage and twine	60

*WALKER COUNTY.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
Boldo Grist Mill	Boldo	flour and grist mill	40
James B. Wakefield	Prospect	flour and grist mill	10
Lewis W. Odom	Oakman	flour and grist mill	10
Mahala E. & Dalton Odom	Parrish	flour and grist mill	10
Joseph Z. Norris	Galloway	flour and grist mill	5
Thomas J. King	Oakman	flour and grist mill	10
Lewis Guthrie	Pocahontas	flour and grist mill	10
Wm. Cobb	Oakman	flour and grist mill	10
Peter McGough	Carbonhill	lumber and timber	10

*WASHINGTON COUNTY.

NAME.	POSTOFFICE.	INDUSTRY.	H. P.
Mrs. Samuel Wilkins	Healing Springs	flour and grist mill	6
Consey's Mill	Healing Springs	lumber and timber mill	10

WILCOX COUNTY.

	NAME.	POSTOFFICE.	INDUSTRY.	H. P.
*	Ward & Grimes, (Pine Barren Creek)	Pineapple	flour and grist	33
*	George A. Barge	Snowhill	flour and grist mill	15
*	J. W. Cooper	Candler	flour and grist mill	16
†	George Barge, (Pine Barren Creek)	Furman	grist mill and gin	
†	Glover & Carter, (Pine Barren Cr.)	Pineapple	grist mill and gin	
†	S. McCormick, (Pine Barren Cr.)	Pineapple	grist mill and gin	
†	D. McIntosh, (Pursley Creek)	Camden	grist mill and gin	

*From U. S. Census, 1900.

†From report of Probate Judge.

WINSTON COUNTY.

	NAME	POSTOFFICE.	INDUSTRY.	H. P.
*	Richard H. Blake	Houston	flour and grist mill	8
*	Thomas O. Partridge	Elk	flour and grist mill	10
*	Wm. D. Shadix, (Sandy Creek)	Double Springs)	flour and grist	4
*	George D. Wilson	Haleysville	flour and grist mill	8
*	Manna A. Posey	Motes	flour and grist mill	10
*	Martin A. & Martha Peak	Peaks Mill	flour and grist mill	10
*	Milligan Mill	Double Springs	flour and grist mill	10
*	James Cantrell	Addison	flour and grist mill	4
*	Burks Mill	Cranal	flour and grist mill	10
†	Nauvoo Mill, (Black Water Creek)	Nauvoo	grist mill and gin	
†	Anderson Ward Mill, (Clear Creek)	Haleysville	flour and grist	
†	J. Calvin Cagle, (Clear Creek)	Double Springs	saw, flour and grist mill and gin	
†	Jonathan Barton Mill, (Clear Creek)	Deer	grist mill	
†	Hadder Mill, (Clear Creek)	Double Springs	grist mill	
†	Posey Mill, (Clear Creek)	Motes	grist mill, saw and gin	
†	S. D. Spain, (Clear Creek)	Malta	grist mill, saw and gin	
†	Gus Posey Mill, (Clear Creek)	Elk	grist mill, saw and gin	
†	Wm. Dodd, (Splunge Creek)	Natural Bridge	grist mill, saw and gin	
†	Kelley Mill, (Black Water Creek)	Lynn	grist mill, saw and gin	
†	Peaks Mill, (Grindstone Creek)	Peaks Mill	grist mill, saw and gin	
†	Jack Curtis, (Sandy Creek)	Double Springs	grist mill, saw and gin	
†	Manley Payne, (Beech Creek)	Gumpond	grist mill, saw and gin	
†	Christian Mill, (Christian Creek)	Peaks Mill	grist mill, saw	

*From U. S. Census, 1900.

†From report of Probate Judge.

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GEOLOGICAL SURVEY OF ALABAMA

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BULLETIN No. [illegible]

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BY

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THE CEMENT RESOURCES OF ALABAMA

BY

[illegible]

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, STATE GEOLOGIST.

BULLETIN No. 8.

The Materials and Manufacture of Portland Cement.

BY

EDWIN C. ECKEL.

The Cement Resources of Alabama.

BY

EUGENE A. SMITH.

MONTGOMERY, ALABAMA
THE BROWN PRINTING COMPANY, PRINTERS AND BINDERS
1904

To His Excellency, GOV. R. M. CUNNINGHAM:

Sir: I have the honor to submit herewith Bulletin No. 8, on the Cement Resources of Alabama; with Preliminary Chapters on the Materials and Manufacture of Portland Cement, by Mr. Edwin C. Eckel, of the United States Geological Survey.

That part of the Report relating specially to the Alabama occurrences was prepared by the writer in coöperation with the United States Geological Survey, and in slightly different form, has been published in Bulletin No. 225, of that Survey. The chapters by Mr. Eckel, which add so much to the value and completeness of the Bulletin, have been generously contributed by him.

Our indebtedness to Senator John T. Morgan is particularly great, since the investigations on which this report is based, were undertaken mainly at his instance, and the coöperation above mentioned, secured through his influence.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

University of Alabama,
July 1, 1904.

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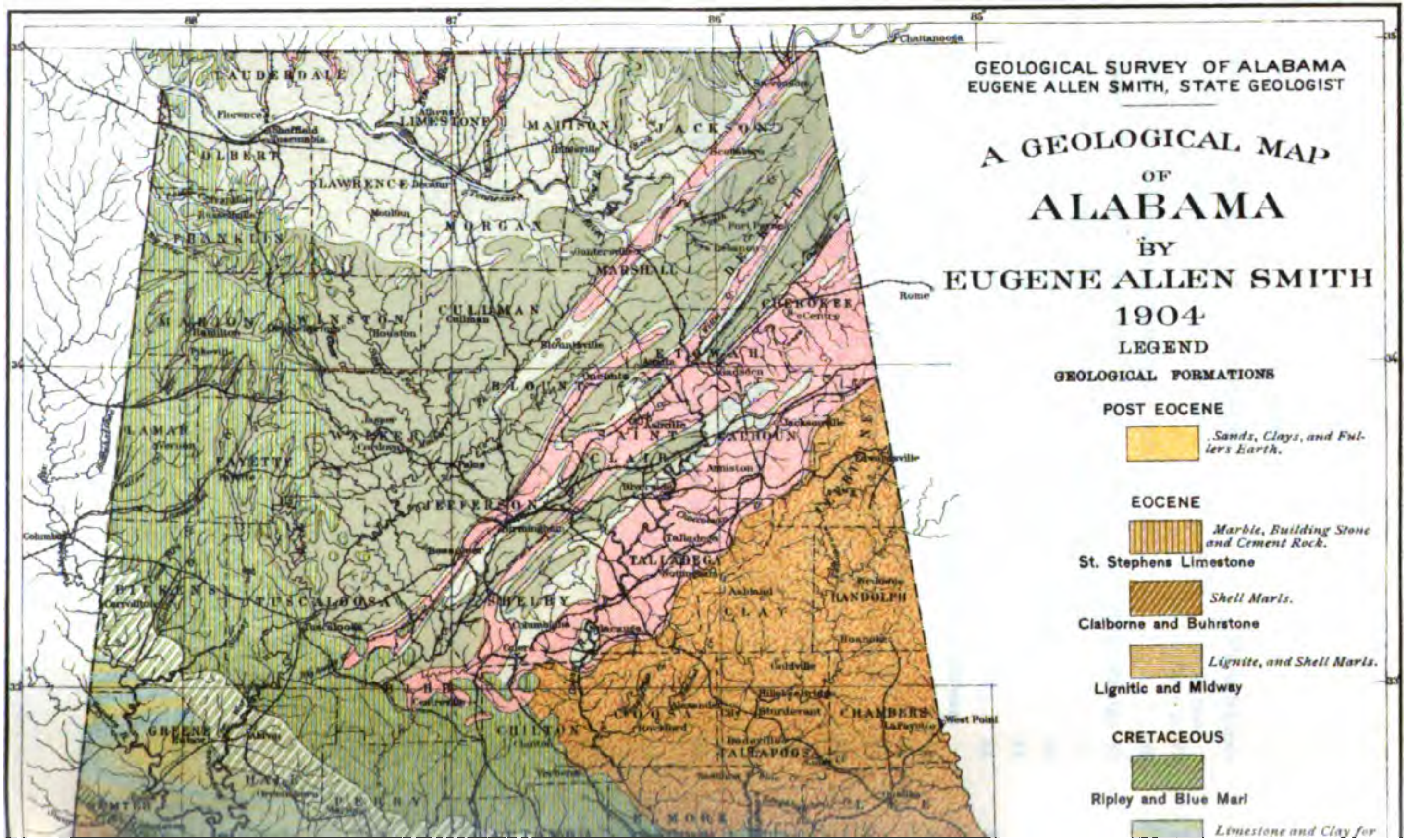
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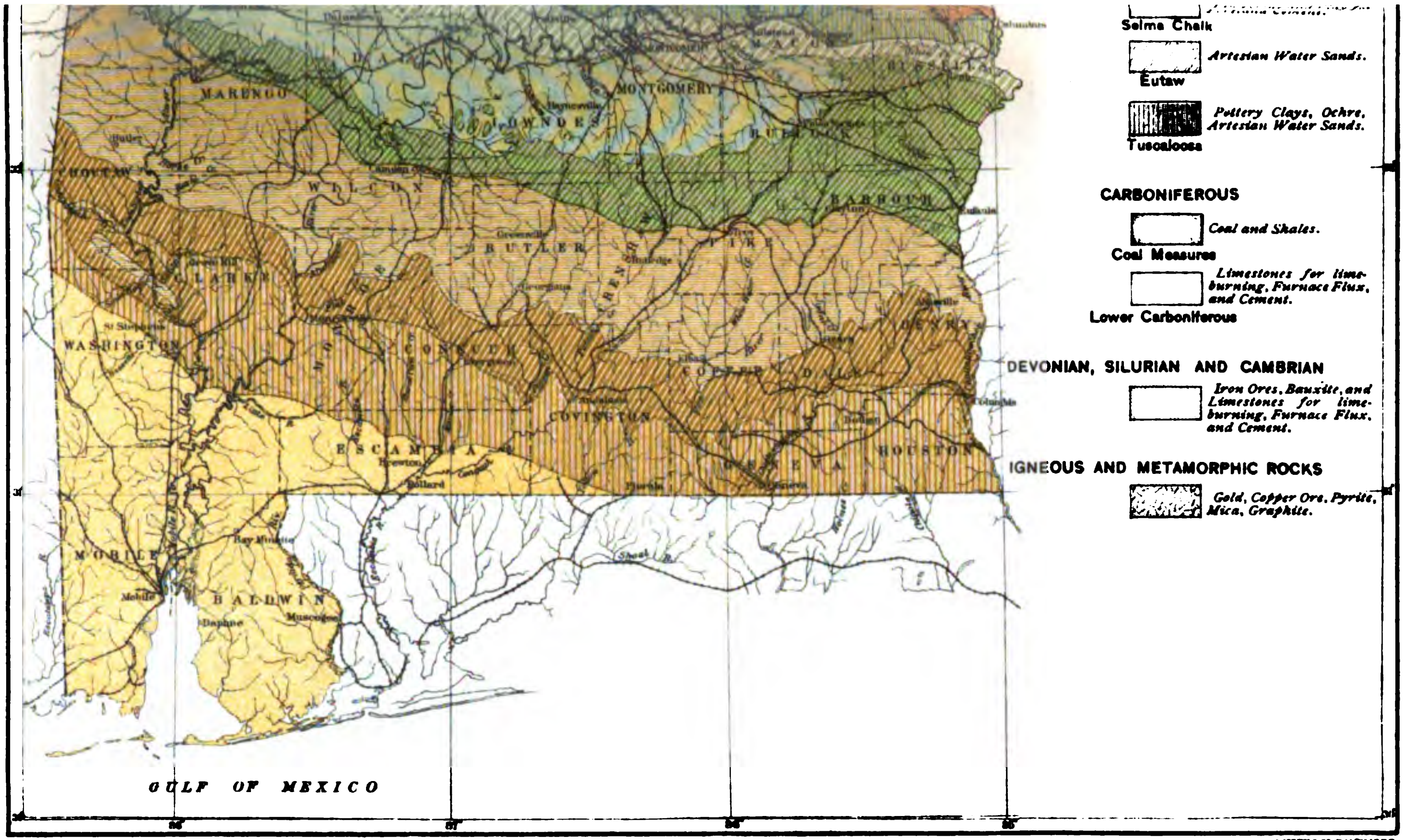
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PART I.

THE MATERIALS AND MANUFACTURE OF PORTLAND CEMENT.*

BY EDWIN C. ECKEL.

[The following paper on the raw materials and methods of manufacture of Portland Cement has been prepared as the result of field work and other investigations carried out by the writer for the United States Geological Survey. Certain sections of the contribution have appeared, in slightly different form, in *Municipal Engineering* during the past two years.]

CHAPTER 1.

THE RELATION OF PORTLAND TO OTHER CEMENTS.

It seems desirable, before taking up the specific subject of Portland cement, to indicate the relationships existing between Portland and other cementing materials. These relationships, both as regards resemblances and differences, seem to be best brought out by the classification presented below. This grouping is based primarily upon the amount of chemical change caused by the process of manufacture and use; and secondarily upon the chemical composition of the cement after setting. As regard is paid to both technologic and commercial considerations, it would seem to be a fairly satisfactory working classification.

GROUP I.—SIMPLE CEMENTS: Including all those cementing materials produced by the expulsion of a liquid or gas from the raw material; and whose setting properties are due to the

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simple reabsorption of the same liquid or gas and the reassumption of original composition; the set cement being therefore similar in composition to the raw material.

Sub-group Ia. Hydrate Cements: Setting properties due to reabsorption of water.

Sub-group Ib. Carbonate Cements: Setting properties due to reabsorption of carbon dioxide.

GROUP II.—COMPLEX CEMENTS: Including all those cementing materials whose setting properties are due to the action of entirely new chemical compounds which were formed during manufacture or use; the set cement being therefore different in composition from the raw material.

Sub-group Ia. Silicate Cements: Setting properties due largely to the formation of silicates.

Sub-group IIb. Oxychloride Cements: Setting properties due to the formation of oxychlorides.

GROUP I—SIMPLE CEMENTS.

The cementing materials included in the present group are those known commercially as "plasters," "hard-finishing cements," and "limes."

The material from which the "plasters" and "hard-finishing cements" are derived is gypsum, a hydrous calcium sulphate; while the limes are derived from limestone, which is essentially calcium carbonate, though usually accompanied by greater or less amounts of magnesium carbonate.

On heating gypsum to a certain temperature, the raw material parts readily with much of its water, leaving an almost anhydrous calcium sulphate, known commercially as plaster-of-Paris. On exposing this plaster to water, it re-hydrates, and again takes the composition of the gypsum from which it was derived.

In like manner limestone, on being sufficiently heated, gives off its carbon dioxide, leaving calcium oxide or "quicklime." This, on exposure to moisture and air carrying carbon dioxide, reabsorbs carbon dioxide and reassumes its original composition, calcium carbonate.

The cementing materials included in this group, therefore,

while differing in composition and properties, agree in certain important points. They are all manufactured by heating a natural raw material sufficiently to remove much or all of its water or carbon dioxide; and, in all, the setting properties of the cementing material are due to the fact that, on exposure to the water or carbon dioxide which has thus been driven off, the cement reabsorbs the previously expelled liquid or gas, and reassumes the chemical composition of the raw material from which it was derived.

Plaster-of-Paris, after setting, is not chemically different from the gypsum from which it was derived; while if the sand, added to avoid shrinkage, be disregarded, hardened lime mortar is nothing more or less than an artificial limestone.

Sub-group Ia. Hydrate Cements.

The materials here included are known in commerce as "plaster-of-Paris," "cement plaster," "Keene's cement," "Parian cement," etc. All of these hydrate cements are based upon one raw material,—gypsum. The partial dehydration of pure gypsum produces plaster-of-Paris. By the addition of gypsum, either by nature or during manufacture, of relatively small amounts of other materials; or by slight variations in the processes of manufacture, the time of setting, hardness. and other important technical properties of the resulting plaster can be changed to a sufficient degree to warrant separate naming and descriptions of the products.

Both the technology and the chemistry of the processes involved in the manufacture of the hydrate cements are simple. The mineral gypsum, when pure, is a hydrous sulphate of lime, of the formula $CaSO_4, 2H_2O$, corresponding to the composition calcium sulphate 79.1%, water 20.9%. Gypsum, as mined, rarely even approximates to this ideal composition, its impurities often amounting to 25% or even more. These impurities, chiefly clayey materials and fragments of quartz and limestone, often exercise an appreciable effect upon the properties of the plaster resulting from burning such impure gypsum.

On burning pure gypsum at a relatively low temperature (350°-400° F.) much of its water of combination is driven off, leaving a partially dehydrated lime sulphate. This, when ground, is plaster of Paris, or if it either naturally or artificial-

ly contains certain impurities, it is called "cement plaster." When either plaster of Paris or cement plaster are mixed with water, the percentage of water which was driven off during calcination is reabsorbed, and the mixture hardens, having again becomes a hydrous sulphate of lime. The processes involved in the manufacture and setting of the dead-burned plasters and hard-finish plasters are slightly more complicated, but the reactions involved are of the same general type.

Sub-group Ib. Carbonate Cements.

The cementing materials falling in the present sub-group are oxides, derived from natural carbonates by the application of heat. On exposure, under proper conditions, to any source of carbon dioxide, the cementing material recorbonates and "sets." In practice the carbon dioxide required for setting is obtained simply by exposure of the mortar to the air. In consequence the set of these carbonate cements, as commonly used, is very slow (owing to the small amount of carbon dioxide which can be taken up from ordinary air); and, what is more important from an engineering point of view, none of the mortar in the interior of a wall ever acquires hardness, as only the exposed portions have an opportunity to absorb carbon dioxide. From the examination of old mortars it has been thought probable that a certain amount of chemical action takes place between the sand and the lime, resulting in the formation of lime silicates; but this effect is slight and of little engineering importance compared with the hardening which occurs in consequence of the reabsorption of carbon dioxide from the air.

Limestone is the natural raw material whose calcination furnishes the cementing materials of this group. If the limestone be an almost pure calcium carbonate it will, on calcination, yield calcium oxide or "quicklime." If, however, the limestone should contain any appreciable percentage of magnesium carbonate, the product will be a mixture of the oxides of calcium and magnesium commercially known as magnesian lime. A brief sketch of the mineralogic relationships of the various kinds of limestone, in connection with the chemistry of lime-burning, will be of service at this point of the discussion.

Pure limestone has the composition of the mineral calcite, whose formula is $CaCO_3$, corresponding to the composition

calcium oxide 56%, carbon dioxide, 44%. In the magnesian limestones part of this calcium carbonate is replaced by magnesium carbonate, the resulting rock therefore having a formula of the type X $CaCO_3$, Y $MgCO_3$. This replacement may reach the point at which the rock has the composition of the mineral dolomite—an equal mixture of the two carbonates, with the formula $CaCO_3$, $MgCO_3$, corresponding to the composition calcium oxide 30.43%, magnesium oxide, 21.74%, carbon dioxide, 47.83%. Limestones may therefore occur with any intermediate amount of magnesium carbonate, and the lime which they produce on calcination will carry corresponding percentages of magnesium oxide, from 0% to 21.74%. Commercially those limes which carry less than 10% of magnesium oxide are, for building purposes, marketable as "pure limes"; while those carrying more than that percentage will show sufficiently different properties to necessitate being marketed as "magnesian limes."

Aside from the question of magnesia, a limestone may contain a greater or lesser amount of impurities. Of these the most important are silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3). These impurities, if present in sufficient quantity, will materially affect the properties of the lime produced, as will be noted under the heads of Hydraulic Limes and Natural Cements.

The Carbonate Cements may be divided into two classes:—

(1) High calcium limes;

(2) Magnesian limes.

High Calcium Limes.—On heating a relatively pure carbonate of lime to a sufficiently high degree, its carbon dioxide is driven off, leaving calcium oxide (CaO) or "quicklime." Under ordinary conditions, the expulsion of the carbon dioxide is not perfectly effected until a temperature of 925° C. is reached. The process is greatly facilitated by blowing air through the kiln, or by the injection of steam. On treating quicklime with water, "slacking" occurs, heat being given off, and the hydrated calcium oxide (CaH_2O_2) being formed. The hydrated oxide will, upon exposure to the atmosphere, slowly reabsorb sufficient carbon dioxide to reassume its original composition as lime carbonate. As this reabsorption can take place

only at points where the mortar is exposed to the air, the material in the middle of thick walls never becomes recarbonated. In order to counteract the shrinkage which would otherwise take place during the drying of the mortar, sand is invariably added in the preparation of lime mortars, and as noted above, it is probable that certain reactions take place between the lime and the sand. Such reactions, however, though possibly contributing somewhat to the hardness of old mortars, are only incidental and subsidiary to the principal cause of setting,—recarbonation. The presence of impurities in the original limestone affects the character and value of the lime produced. Of these impurities, the presence of silica and alumina in sufficient quantities will give hydraulic properties to the resulting limes; such materials will be discussed in the next group as Hydraulic Limes and Natural Cements.

Magnesian Limes.—The presence of any considerable amount of magnesium carbonate in the limestone from which a lime is obtained has a noticeable effect upon the character of the product. If burned at the temperature usual for a pure limestone, magnesian limestones give a lime which slakes slowly without evolving much heat, expands less in slaking, and sets more rapidly than pure lime. To this class belongs the well known and much used limes of Canaan (Conn.); Tuckahoe, Pleasantville and Ossining, (N. Y.); various localities in New Jersey and Ohio; Cedar Hollow (Penn.), and Chewacla (Ala.) Under certain conditions of burning, pure magnesian limestone yields hydraulic products, but in this case, as in the case of the product obtained by burning pure magnesite, the set seems to be due to the formation of a hydroxide rather than of a carbonate. Magnesian limestones carrying sufficient silica and alumina will give, on burning, a hydraulic cement falling in the next group under the head of Natural Cements.

GROUP II—COMPLEX CEMENTS.

The cementing materials grouped here as Silicate or Hydraulic Cements, include all those materials whose setting properties are due to the formation of new compounds, during manufacture or use, and not to the mere reassumption of the original composition of the material from which the cement was made. These new compounds may be formed either by chemical change

during manufacture or by chemical interaction, in use, of materials which have merely been mechanically mixed during manufacture.

In the class of silicate cements are included all the materials commonly known as cements by the engineer (natural cements, Portland cement, pozzuolanic cements), together with the hydraulic limes.

Though differing widely in raw material, methods of manufacture and properties, the silicate cements agree in two prominent features: they are all hydraulic (though in very different degrees); and this property of hydraulicity is, in all, due largely or entirely to the formation of tri-calcic silicate ($3\ CaO\ SiO_2$). Other silicates of lime, as well as silico-aluminates, may also be formed; but they are relatively unimportant, except in certain of the natural cements and hydraulic limes where the lime-aluminates may be of greater importance than is here indicated. This will be recurred to in discussing the groups named.

The silicate cements are divisible, on technologic grounds, into four distinct classes. The basis for this division is given below. It will be seen that the first named of these classes (the pozzuolanic cements) differs from the other three very markedly inasmuch as its raw materials are not calcined after mixture; while in the last three classes the raw materials are invariably calcined after mixture. The four classes differ somewhat in composition, but more markedly in methods of manufacture and in the properties of the finished cements.

Classes of Silicate Cements.

1. Pozzuolanic Cements*: Produced by the mechanical mixture, without calcination, of slaked lime and a silico-aluminous material (the latter being usually a volcanic ash or blast-furnace slag.)

2. Hydraulic Limes: Produced by the calcination, at a temperature not much higher than that of decarbonation, of a siliceous limestone so high in lime carbonate that a considerable amount of free lime appears in the finished product.

*Also written Puzzolan.

3. Natural Cements: Produced by the calcination, at a temperature between those of decarbonation and clinkering, of a siliceous limestone (which may also carry notable amounts of alumina and of magnesium carbonate) in which the lime carbonate is so low, relatively to the silica and alumina, that little or no free lime appears in the cement.

4. Portland Cements: Produced by the calcination, at the temperature of semi-vitrefaction ("clinkering") of an artificial mixture of calcareous with silico-aluminous materials, in the proportion of about three parts of lime carbonate to one part of clayey material.

NATURAL CEMENTS.

Natural cements are produced by burning a naturally impure limestone, containing from 15 to 40 per cent. of silica, alumina, and iron oxide. This burning takes place at a comparatively low temperature, about that of ordinary lime burning. The operation can therefore be carried on in a kiln closely resembling an ordinary lime kiln. During the burning the carbon dioxide of the limestone is almost entirely driven off, and the lime combines with the silica, alumina, and iron oxide, forming a mass containing silicates, aluminates, and ferrites of lime. In case the original limestone contained much magnesium carbonate, the burned rock will also contain a corresponding amount of magnesia and magnesian compounds.

After burning, the burned mass will not slack if water be added. It is necessary, therefore, to grind it quite finely. After grinding, if the resulting powder (-natural cement) be mixed with water it will harden rapidly. This hardening or setting will also take place under water. The natural cements differ from ordinary limes in two noticeable ways:

(1) The burned mass does not slack on the addition of water.

(2) After grinding, the powder has hydraulic properties, *i. e.*, if properly prepared, it will set under water.

Natural cements are quite closely related to both hydraulic limes on the one hand, and Portland cement on the other, agreeing with both in the possession of hydraulic properties. They differ from hydraulic limes, however, in that the burned natural cement rock will not slake when water is poured on it.

The natural cements differ from Portland cements in the following important particulars:

(1) Natural cements are not made by burning carefully prepared and finely ground artificial mixtures, but by burning masses of natural rock.

(2) Natural cements, after burning and grinding, are usually yellow to brown in color and light in weight, their specific gravity being about 2.7 to 2.9; while Portland cement is commonly blue to gray in color and heavier, its specific gravity ranging from 3.0 to 3.2.

(3) Natural cements are always burned at a lower temperature than Portland, and commonly at a *much* lower temperature, the mass of rock in the kiln never being heated high enough to even approach the fusing or clinkering point.

(4) In use, natural cements set more rapidly than Portland cement, but do not attain such a high ultimate strength.

(5) In composition, while Portland cement is a definite product whose percentages of lime, silica, alumina and iron oxide vary only between narrow limits, various brands of natural cements will show very great differences in composition.

The material utilized for natural cement manufacture is invariably a clayey limestone, carrying from 13 to 35 per cent. of clayey material, of which 10 to 22 per cent. or so is silica, while alumina and iron oxide together may vary from 4 to 16 per cent. It is the presence of these clayey materials which give the resulting cement its hydraulic properties. Stress is often carelessly or ignorantly laid on the fact that many of our best known natural cements carry large percentages of magnesia, but it should, at this date, be realized that magnesia (*in natural cements at least*) may be regarded as being almost exactly interchangeable with lime, so far as the hydraulic properties of the product are concerned. The presence of magnesium carbonate in a natural cement rock is then merely incidental, while the silica, alumina and iron oxide are essential. The 30 per cent. or so of magnesium carbonate which occurs in the cement rock of the Rosendale District, N. Y., could be replaced by an equal amount of lime carbonate, and the burnt stone would still give a hydraulic product. If, however, the clayey portion (silica, alumina, and iron oxide) of the Rosendale rock could be removed, leaving only the magnesium and lime carbonates, the

burnt rock would lose all of its hydraulic properties and would yield simply a magnesian lime.

This point has been emphasized because many writers on the subject have either explicitly stated or implied that it is the magnesian carbonate of the Rosendale, Akron, Louisville, Utica, and Milwaukee rocks that causes them to yield a natural cement on burning.

PORTLAND CEMENT.

Portland cement is produced by burning a finely ground artificial mixture containing essentially lime, silica, alumina, and iron oxide, in certain definite proportions. Usually this combination is made by mixing limestone or marl with clay or shale, in which case about three times as much of the lime carbonate should be present in the mixture as of the clayey materials. The burning takes place at a high temperature, approaching 3,000° F., and must, therefore, be carried on in kilns of special design and lining. During the burning, combination of the lime with silica, alumina, and iron oxide takes place. The product of the burning is a semi-fused mass called clinker, and consisting of silicates, aluminates, and ferrites of lime in certain definite proportions. This clinker must be finely ground. After such grinding the powder (—Portland cement) will set under water.

As noted above, under the head of Natural Cements, Portland cement is blue to gray in color, with a specific gravity of 3.0 to 3.2, and sets more slowly than natural cements, but soon attains a higher tensile strength.

PUZZOLAN CEMENTS.

The cementing materials included under this name are made by mixing powdered slaked lime with either a volcanic ash or a blast-furnace slag. The product is therefore simply a mechanical mixture of two ingredients, as the mixture is not burned at any stage of the process. After mixing, the mixture is finely ground. The resulting powder (Puzzolan cement) will set under water.

Puzzolan cements are usually light bluish to light yellow in color, and of lower specific gravity and less tensile strength than Portland cement. They are better adapted to use under water than to use in air.

CHAPTER 2.

PORTLAND CEMENT: DEFINITION, COMPOSITION AND CONSTITUTION.

In the following section various possible raw materials for Portland cement manufacture will be taken up, and their relative suitability for such use will be discussed. In order that the statements there made may be clearly understood, it will be necessary to preface this discussion by a brief explanation regarding the composition and constitution of Portland cement.

Use of term Portland.—While there is a general agreement of opinion as to what is understood by the term Portland cement, a few points of importance are still open questions. The definitions of the term given in specifications are in consequence often vague and unsatisfactory.

It is agreed that the cement mixture must consist essentially of lime, silica, and alumina in proportions which can vary but slightly; and that this mixture must be burned at a temperature which will give a semi-fused product—a "clinker." These points must therefore be included in any satisfactory definition. The point regarding which there is a difference of opinion is whether or not cements made by burning a natural rock can be considered true Portlands. The question as to whether the definition of Portland cement should be drawn so as to include or exclude such products is evidently largely a matter of convention: but, unlike most conventional issues, the decision has very important practical consequences. The question at issue may be stated as follows:

If we make artificial mixture of the raw materials and a very high degree of burning the criteria on which to base our definition, we must in consequence of that decision exclude from the class of Portland cements certain well known products, manufactured at several points in France and Belgium by burning a natural rock, without artificial mixture, and at a considerably lower temperature than is attained in ordinary Portland cement practice. These "natural Portlands" of France and Belgium

have always been considered Portland cements by the most critical authorities, though all agree that they are not particularly *high grade* Portlands. So that a definition, based upon the criteria above named, will of necessity exclude from our class of Portland cements some very meritorious products.

There is no doubt that in theory a rock could occur, containing lime, silica, and alumina in such correct proportions as to give a good Portland cement on burning. Actually, however, such a perfect cement rock is of extremely rare occurrence. As above stated, certain brands of French and Belgian "Portland" cements are made from such natural rocks, without the addition of any other material; but these brands are not particularly high grade, and in the better Belgian cements the composition is corrected by the addition of other materials to the cement rock, before burning.

The following definition of Portland cement is of importance because of the large amount of cement which will be accepted annually under the specifications* in which it occurs. It is also of interest as being the nearest approach to an official government definition of the material that we have in this country:

"By a Portland cement is meant the product obtained from the heating or calcining up to incipient fusion of intimate mixtures, either natural or artificial, of argillaceous with calcareous substances, the calcined product to contain at least 1.7 times as much of lime, by weight, as of the materials which give the lime its hydraulic properties, and to be finely pulverized after said calcination, and thereafter additions or substitutions for the purpose only of regulating certain properties of technical importance to be allowable to not exceeding 2 per cent. of the calcined product."

It will be noted that this definition does not require pulverizing or artificial mixing of the materials prior to burning. It seems probable that the Belgian "natural Portlands" were kept in mind when these requirements were omitted. In dealing with American made cements, however,—and the specifications are headed "Specifications for American Portland Cement,"—it is a serious error to omit these requirements. No true Portland cements are at present manufactured in America from natural

*Professional Paper, No. 28, Corps of Engineers, U.S.A., p. 30.

mixtures, without pulverizing and artificially mixing the materials prior to burning. Several plants, however, have placed on the market so-called Portland cements made by grinding up together the underburned and overburned materials formed during the burning of natural cements. Several of these brands contain from 5 to 15 per cent. of magnesia; and under no circumstances can they be considered true Portland cements.

In view of the conditions above noted, the writer believes that the following definition will be found more satisfactory than the above quoted:

Definition of Portland cement.—Portland cement is an artificial product obtained by finely pulverizing the clinker produced by burning to semi-fusion an intimate mixture of finely ground calcareous and argillaceous material, this mixture consisting approximately of one part of silica and alumina to three parts of carbonate of lime (or an equivalent amount of lime oxide.)

Composition and Constitution.—Portland cement may be said to tend toward a composition approximating to pure tricalcic silicate ($3\ CaO, SiO_2$) which would correspond to the proportion CaO 73.6%, SiO_2 26.4%. As can be seen, however, from the published analyses, actual Portland cements as at present made differ in composition very markedly from this. Alumina is always present in considerable quantity, forming with part of the lime, the dicalcic aluminate ($2\ CaO, SiO_2$). This would give, as stated by Newberry, for the general formula of a pure Portland.

$$X\ (3\ CaO, SiO_2),\ Y\ (2\ CaO, Al_2O_3).$$

But the composition is still further complicated by the presence of accidental impurities, or intentionally added ingredients. These last may be simply adulterants, or they may be added to serve some useful purpose. Calcium sulphate is a type of the latter class. It serves to retard the set of the cement, and, in small quantities, appears to have no injurious effect which would prohibit its use for this purpose. In dome kilns, sufficient sulphur trioxide is generally taken up by the cement from the fuel gases to obviate the necessity for the later addition of calcium sulphate, but in the rotary kiln its addition to the ground cement, in the form of either powdered gypsum or plaster-of-Paris, is a necessity.

Iron oxide, within reasonable limits, seems to act as a substitute for alumina, and the two may be calculated together. Magnesium carbonate is rarely entirely absent from limestones or clays, and magnesia is therefore almost invariably present in the finished cement. Though magnesia, when magnesium carbonate is burned at low temperature, is an active hydraulic material, it does not combine with silica or alumina at the clinkering heat employed in Portland cement manufacture. At the best it is an inert and valueless constituent in the cement; many regard it as positively detrimental in even small amounts, and because of this feeling manufacturers prefer to carry it as low as possible. Newberry has stated that in amounts of less than 3½% it is harmless,—and American Portlands from the Lehigh district usually reach well up toward that limit. In European practice it is carried somewhat lower.

CHAPTER 3.

RAW MATERIALS. GENERAL CONSIDERATIONS.

For the purposes of the present chapter, it will be sufficiently accurate to consider that a Portland cement mixture, when ready for burning, will consist of about 75 per cent. of lime carbonate ($Ca\ CO_3$) and 20 per cent. of silica (SiO_2), alumina (Al_2O_3) and iron oxide (Fe_2O_3) together, the remaining 5 per cent. including any magnesium carbonate, sulphur and alkalies that may be present.

The essential elements which enter into this mixture,—lime, silica, alumina and iron,—are all abundantly and widely distributed in nature, occurring in different forms in many kinds of rocks. It can, therefore, be readily seen that, theoretically, a satisfactory Portland cement mixture could be prepared by combining, in an almost infinite number of ways and proportions, many possible raw materials. Obviously, we, too, might expect to find perfect graduations in the *artificialness* of the mixture, varying from the one extreme where a natural rock of absolutely correct composition was used to the other extreme where two or more materials, in nearly equal amounts, are required to make a mixture of correct composition.

The almost infinite number of raw materials which are theoretically available are, however, reduced to a very few in practice under existing commercial conditions. The necessity for making the mixture as cheaply as possible rules out of consideration a large number of materials which would be considered available if chemical composition was the only thing to be taken into account. Some materials otherwise suitable are too scarce; some are too difficult to pulverize. In consequence, a comparatively few combinations of raw materials are actually used in practice.

In certain localities deposits of argillaceous (clayey) limestone or "cement rock" occur, in which the lime, silica, alumina and iron oxide exist in so nearly the proper proportions that only a relatively small amount (say 10 per cent. or so) of other material is required in order to make a mixture of correct composition.

In the majority of plants, however, most or all of the necessary lime is furnished by one raw material, while the silica, alumina and iron oxide are largely or entirely derived from another raw material. The raw material which furnished the lime is usually natural,—a limestone, chalk or marl; but occasionally an artificial product is used, such as the chemically precipitated lime carbonate which results as waste from alkali manufacture. The silica, alumina and iron oxide of the mixture are usually derived from clays, shales or slates; but in a few plants blast-furnace slag is used as the silico-aluminous ingredient in the manufacture of true Portland cement.

The various combinations of raw material which are at present used in the United States in the manufacture of Portland cement may be grouped under six heads. This grouping is as follows:

1. Argillaceous limestone (cement rock) and pure limestone.
2. Pure hard limestone and clay or shale.
3. Soft chalky limestone and clay.
4. Marl and clay.
5. Alkali waste and clay.
6. Slag and limestone.

ORIGIN AND GENERAL CHARACTERS OF LIMESTONE.

The cement materials which are described in the four following sections as argillaceous limestone or cement rock, pure hard limestone, chalk, and marl, though differing sufficiently in their physical and economic characters to be discussed separately and under different names, agree in that they are all forms of limestone. The origin, chemical composition, physical characters, and properties of limestone will, therefore, be briefly taken up in the present chapter to serve as an introduction to the more detailed statements concerning the various types of limestone to be found in the succeeding chapters.

*Origin of limestones.**—Limestones have been formed largely by the accumulation at the sea bottom of the calcareous re-

*For a more detailed discussion of this subject the reader will do well to consult Chapter VIII of Prof. J. F. Kemp's "Handbook of Rocks."

mains of such organisms as the foraminifera, corals, and mollusks. Most of the thick and extensive limestone deposits of the United States were probably deep-sea deposits formed in this way. Many of these limestones still show the fossils of which they were formed, but in others all trace of organic origin has been destroyed by the fine grinding to which the shells and corals were subjected before their deposition at the sea-bottom. It is probable also that part of the calcium carbonate of these limestones was a purely chemical deposit from solution, cementing the shell fragments together.

A far less extensive class of limestones—though important in the present connection—owe their origin to the indirect action of organisms. The "marls," so important today as Portland cement materials, fall in this class. As the class is of limited extent, however, its method of origin may be dismissed here, but will be described later in the section on Marls.

Deposition from solution by purely chemical means has unsdoubtedly given rise to numerous limestone deposits. When this deposition took place in caverns or in the open air, it gave rise to onyx deposits and to the "travertine marls" of certain Ohio and other localities; when it took place in isolated portions of the sea through the evaporation of the sea water it gave rise to the limestone beds which so frequently accompany deposits of salt and gypsum.

Varieties of limestone.—A number of terms are in general use for the different varieties of limestone, based upon differences of origin, texture, composition, etc. The more important of these terms will be briefly defined.

The *marbles* are limestones which, through the action of heat and pressure, have become more or less distinctively crystalline. The term *marl*, as at present used in cement manufacture, is applied to a loosely cemented mass of lime carbonate formed in lake basins as described on a later page. *Calcareous tufa* and *travertine* are more or less compact limestones deposited by spring or stream waters along their courses. *Oolitic* limestones, so called because of their their resemblance to a mass of fish-roe, are made up of small rounded grains of lime carbonate. *Chalk* is a fine-grained limestone composed of finely comminuted shells, particularly those of the foraminifera. The presence of much silica gives rise to a *siliceous* or *cherty* limestone. If the

silica present is in combination with alumina, the resulting limestone will be *clayey* or *argillaceous*.

Chemical composition of limestone—A theoretically pure limestone is merely a massive form of the mineral calcite. Such an ideal limestone would therefore consist entirely of calcium carbonate or carbonate of lime, with the formula $CaCO_3$ ($CaO+CO_2$), corresponding to the composition calcium oxide (CaO) 56 per cent.; carbon dioxide or carbonic acid (CO_2) 44 per cent.

As might be expected, the limestones we have to deal with in practice depart more or less widely from this theoretical composition. These departures from ideal purity may take place along either of two lines,—

a. The presence of magnesia in place of part of the lime;

b. The presence of silica, iron, alumina, alkalies, or other impurities.

It seems advisable to discriminate between these two cases, even though a given sample of limestone may fall under both heads, and they will therefore be discussed separately.

a. *The presence of magnesia in place of part of the lime.*—The theoretically pure limestones are, as above noted, composed entirely of calcium carbonate and correspond to the chemical formula $CaCO_3$. Setting aside for the moment the question of the presence or absence of such impurities as iron, alumina, silica, etc., it may be said that lime is rarely the only base in a limestone. During or after the formation of the limestone a certain percentage of magnesia is usually introduced in place of part of the lime, htus giving a more or less magnesian limestone. In the magnesian limestones part of this calcium carbonate is replaced by magnesium carbonate ($MgCO_3$), the general formula for a magnesian limestone being therefore

$$x\ Ca\ CO_3 + y\ Mg\ CO_3.$$

In this formula x may vary from 100% to zero, while y will vary inversely from zero to 100%. In the particular case of this replacement where the two carbonates are united in equal *molecular* proportions, the resultant rock is called dolomite. It has the formula,—$CaCO_3$, $MgCO_3$—corresponding to the composition calcium carbonate 54.35 per cent.; magnesium carbonate 45.65 per cent. In the case where the calcium carbonate has been entirely replaced by magnesium carbonate, the resulting

pure carbonate of magnesia is called magnesite, having the formula $MgCO_3$ and the composition magnesia (MgO) 47.6 per cent.; carbon dioxide (CO_2), 52.4 per cent.

Rocks of this series may therefore vary in composition from pure calcite-limestones at one end of the series to pure magnesite at the other. The term limestone has, however, been restricted in general use to that part of the series lying in composition between calcite and dolomite, while all those more uncommon phases carrying more magnesium carbonate than the 45.65 per cent. of dolomite are usually described simply as impure magnesites.

The presence of much magnesia in the finished cement is considered undesirable, 3½ per cent. being the maximum permissible under most specifications, and therefore the limestone to be used in Portland cement manufacture should carry not over 5 to 6 per cent. of magnesium carbonate.

Though magnesia is often described as an "impurity" in limestone, this word, as can be seen from the preceding statements, hardly expresses the facts in the case. The magnesium carbonate present, whatever its amount, simply serves to replace an equivalent amount of calcium carbonate, and the resulting rock, whether little or much magnesia is present, is still a pure carbonate rock. With the impurities to be discussed in later paragraphs, however, this is not the case. Silica, alumina, iron, sulphur, alkalies, etc., when present, are actual impurities, not merely chemical replacements of part of the calcium carbonate.

b. *The presence of silica, iron, alumina, alkalies, and other impurities.*—Whether a limestone consists of pure calcium carbonate or more or less of magnesium carbonate, it may also contain a greater or lesser amount of distinct impurities. From the point of view of the cement manufacturer, the more important of these impurities are silica, alumina, iron, alkalies, and sulphur, all of which have a marked effect on the value of the limestone as a cement material. These impurities will therefore be taken up in the order in which they are named above.

The silica in a limestone may occur either in combination with alumina, as a clayey impurity, or not combined with alumina. As the effect on the value of the limestone would be very different in the two cases, they will be taken up separately.

Silica alone.—Silica, when present in a limestone containing no alumina, may occur in one of three forms, and the form in

which it occurs is of great importance in connection with cement manufacture.

(1) In perhaps its commonest form, silica is present in nodules, masses or beds of flint or chert. Silica occurring in this form will not readily enter into combination with the lime of a cement mixture, and a cherty or flinty limestone is therefore almost useless in cement manufacture.

(2) In a few cases, as in the hydraulic limestone of Teil, France, a large amount of silica is present and very little alumina; notwithstanding which the silica readily combines with the lime on burning. It is probable that in such cases the silica is present in the limestone in a very finely divided condition, or possibly as hydrated silica, possibly as the result of chemical precipitation or of organic action. In the majority of cases, however, a highly siliceous limestone will not make a cement on burning unless it contains alumina in addition to the silica.

(3) In the crystalline limestone (marbles) and less commonly in uncrystalline limestones, whatever silica is present may occur as a complex silicate in the form of shreds of mica, hornblende, or other silicate mineral. In this form silicate is somewhat intractable in the kiln, and mica and other silicate minerals are therefore to be regarded as inert and useless impurities in a cement rock. These silicates will flux at a lower temperature than pure silica and are thus not so troublesome as flint or chert. They are, however, much less serviceable than if the same amount of silica were present in combination with alumina as a clay.

Silica with alumina.—Silica and alumina, combined in the form of clay, are common impurities in limestone, and are of special interest to the cement manufacturer. The best known example of such an argillaceous limestone is the cement rock of the Lehigh district of Pennsylvania. Silica and alumina, when present in this combined form, combine readily with the lime under the action of heat, and an argillaceous limestone therefore forms an excellent basis for a Portland cement mixture.

Iron.—Iron when present in a limestone occurs commonly as the oxide (Fe_2O_3), or sulphide (FeS_2); more rarely as iron carbonate or in a complex silicate. Iron in the oxide, carbonate or silicate form, is a useful flux, aiding in the combination of the

lime and silica in the kiln. When present as a sulphide, in the form of the mineral pyrite it is to be avoided in quantities over 2 or 3 per cent.

Physical characters of limestones.—In texture, hardness, and compactness, the limestones vary from the loosely consolidated marls through the chalks to the hard compact limestones and marbles. Parallel with these variations are variations in absorptive properties and density. The chalky limestones may run as low in specific gravity as 1.85, corresponding to a weight of say 110 pounds per cubif oot, while the compact limestones commonly used for building purposes range in specific gravity between 2.3 and 2.9, corresponding approximately to a range in weight of from 140 to 185 pounds per cubic foot.

From the point of view of the Portland cement manufacturer, these variations in physical properties are of economic interest chiefly in their bearing upon two points: the percentage of water carried by the limestone as quarried, and the ease with which the rock may be crushed and pulverized. To some extent the two properties counterbalance each other; the softer the limestone the more absorbent is it likely to be. These purely economic features will be discussed in more detail in later chapters.

Effect of heating on limestone.—On heating a non-magnesian limestone to or above 300° C., its carbon dioxide will be driven off, leaving quicklime (calcium oxide, CaO). If a magnesian limestone be similarly treated, the product would be a mixture of calcium oxide and magnesium oxide (MgO). The rapidity and perfection of this decomposition can be increased by passing steam or air through the burning mass. In practice this is accomplished either by the direct injection of air or steam, or more simply by thoroughly wetting the limestone before putting it into the kiln.

If, however, the limestone contains an appreciable amount of silica, alumina and iron, the effects of heat will not be of so simple a character. At temperature of 800° C. and upwards these clayey impurities will combine with the lime oxide, giving silicates, aluminates and related salts of lime. In this manner a natural cement will be produced. An artificial mixture of certain and uniform composition, burned at a higher temperature, will give a Portland cement, the details of whose manufacture are discussed on later pages.

CHAPTER 4.

RAW MATERIALS IN DETAIL.

Argillaceous Limestone: Cement Rock.

An argillaceous limestone containing approximately 75 per cent. of lime carbonate and 20 per cent. of clayey materials (silica, alumina, and iron oxide), would, of course, be the ideal material for use in the manufacture of Portland cement, as such rock would contain within itself in the proper proportions all the ingredients necessary for the manufacture of a good Portland. It would require the addition of no other material, but when burnt alone would give a good cement. This ideal cement material is, of course, never realized in practice, but certain deposits of argillaceous limestone approach the ideal composition very closely.

The most important of these argillaceous limestone or "cement rock" deposits is, at present, that which is so extensively utilized in Portland cement manufacture in the "Lehigh district" of Pennsylvania and New Jersey. As this area still furnishes about two-thirds of all the Portland cement manufactured in the United States, its raw materials will be described in some detail.

Cement rock of the Lehigh district.—The Lehigh district of the cement trade comprises parts of Berks, Lehigh, and Northampton counties, Pennsylvania, and of Warren county, New Jersey. Within this relatively small area about twenty Portland cement mills are located, producing slightly over two-thirds of the entire American output. As deposits of the cement rock used by these plants extend far beyond the present "Lehigh district," a marked extension of the district will probably take place as the needs for larger supplies of raw material becomes more apparent.

The "cement rock" of the Lehigh district is a highly argillaceous limestone of Trenton (Lower Silurian) age. The formation is about 300 feet in thickness in this area. The rock is a very dark gray in color and usually has a slaty fracture. In composition it ranges from about 60 per cent. lime carbonate

with 30 per cent. of clayey material, up to say 80 per cent. lime carbonate with 15 per cent. of silica, alumina and iron. The lower beds of the formation are always higher in lime carbonate than are the beds nearer the top of the formation. The content of magnesium carbonate in these cement rocks is always high, (as Portland cement materials go), ranging from 3 to 6 per cent.

Near, and in some cases immediately underlying these cement beds, are beds of purer limestone ranging from 85 to 96 per cent. lime carbonate. The usual practice in the Pennsylvania and New Jersey plants has been therefore to mix a relatively small amount of this purer limestone with the low lime "cement rock" in such proportions as to give a cement mixture of proper composition.

The economic and technologic advantages of using such a combination of materials are very evident. Both the pure limestone and the cement rock, particularly the latter, can be quarried very easily and cheaply. As quarried they carry but little water so that the expense of dryidg them is slight. The fact that about four-fifths of the cement mixture will be made up of a natural cement rock permits coarser granding of the raw mixture than would be permissible in plants using pure limestone or marl with clay. This point is more fully explained on a later page. It seems probable, also, that when using a natural cement rock as part of the mixture the amount of fuel necessary to clinker the mixture is less than when pure limestone is mixed with clay.

Such mixtures of argillaceous limestone or "cement rock" with a small amount of pure limestone evidently possess important advantages over mixtures of pure hard limestone or marl with clay. They are, on the other hand, less advantageous as cement materials than the chalky limestones discussed on later pages.

The analyses in Table 2 are fairly representative of the materials employed in the Lehigh district. The first four analyses are of "cement rock"; the last two are of the purer limestone used for mixing with it.

Analyses of Lehigh district cement materials.

	Cement rock				Limestone	
Silica (SiO_2)	10.02	9.52	14.52	16.10	3.02	1.98
Alumina (Al_2O_3) / Iron Oxide (Fe_2O_3)	6.26	4.72	6.52	2.20	1.90	0.70
Lime carbonate ($CaCO_3$)	78.65	80.71	73.52	76.23	92.05	95.15
Magnesium carbonate ($MgCO_3$)	4.71	4.92	4.69	3.54	3.04	2.03

"Cement rock" in other parts of the United States.—Certain Portland cement plants, particularly in the western United States, are using combinations of materials closely similar to those in the Lehigh district. Analyses of the materials used at several of these plants are given in Table III.

Analyses of "cement rock" materials from the western United States.

	Utah.		California		Colorado	
	Cement rock	Limestone	Cement rock	Limestone	Cement rock	Limestone
Silica (SiO_2)	21.2	6.8	20.06	7.12	14.20	
Alumina (Al_2O_3)	8.0	3.0	10.07	2.36	5.21	
Iron Oxide (Fe_2O_3)			3.39	1.16	1.73	
Lime carbonate ($CaCO_3$)	62.08	89.8	63.40	87.70	75.10	88.0
Magnesium carbonate ($MgCO_3$)	3.8	0.76	1.54	0.84	1.10	

In addition to the "cement rocks" noted in this chapter, it is necessary to call attention to the fact that many of the chalky limestones discussed on page 26 are sufficiently argillace-

ous to be classed as 'cement rocks:" Because of their softness, however, all the chalky limestones will be described together.

Pure hard limestones.

Soon after the American Portland cement industry had become fairly well established in the Lehigh district, attempts were made in New York State to manufacture Portland cement from a mixture of pure limestone and clay. These attempts were not commercially successful, and although their lack of success was not due to any defects in the limestone used, a certain prejudice arose against the use of the hard limestones. In recent years, however, this has disappeared, and a very large proportion of the American output is now made from mixtures of limestone with clay or shale. (See page 21 for comparative figures.) This reëstablishment in favor of the hard limestones is doubtless due, in great part, to recent improvements in grinding machinery, for the purer limestones are usually much harder than argillaceous limestones like the Lehigh district "cement rock," and it was very difficult to pulverize them finely and cheaply with the crushing appliances in use when the Portland cement industry was first started in America.

A series of analyses of representative pure hard limestones, together with analyses of the clays or shales with which they are mixed, is given in the table.

Analyses of pure hard limestones and clayey materials.

	Limestones.			
Silica (SiO_2)	1.72	0.86	0.56	0.40
Alumina (Al_2O_2)	1.63	0.63	1.23	0.44
Iron oxide (Fe_2O_3)	6.59	1.03	0.29	
Lime carbonate ($CaCO_3$)	90.58	97.06	97.23	97.99
Magnesium carbonate ($MgCO_3$)	....	....	0.75	0.42

	Clays and Shales.			
Silica (SiO_2)	63.56	55.80	56.30	60.00
Alumina (Al_2O_2)				23.36
Iron oxide (Fe_2O_3)	27.32	30.20	29.86	4.32
Lime carbonate ($CaCO_3$)	3.60	2.54	....	1.70
Magnesium carbonate ($MgCO_3$)	2.60	....	....	1.50

The first limestone analysis given in the above table represents a curious type, used in several plants in the Middle West. As will be noted, it is a relatively impure limestone, but its principal impurity is iron oxide. It contains 8.22 per cent. of iron oxide and alumina, as compared with 1.72 per cent. of silica; and therefore demands great care in the selection of a suitable high-silica clay to mix with it.

Soft Limestones: Chalk.

Origin and general character.—Chalk, properly speaking, is a pure carbonate of lime composed of the remains of the shells of minute organisms, among which those of foraminifere are especially prominent. The chalks and soft limestones discussed in this chapter agree, not only in having usually originated in this way, but also in being rather soft and therefore readily and cheaply crushed and pulverized. As Portland cement materials they are, therefore, almost ideal. One defect, however, which to a small extent counterbalances their obvious advantages is the fact that most of these soft, chalky limestones absorb water quite readily. A chalky limestone which in a dry season will not carry over 2 per cent. of moisture as quarried, may, in consequence of prolonged wet weather show as high as 15 or 20 per cent. of water. This difficulty can, of course, be avoided if care be taken in quarrying to avoid unnecessary exposure to water and, if necessary, to provide facilities for storing a supply of the raw materials during wet seasons.

Geographic and geologic distribution in the United States.—The chalks and chalky limestones are confined almost entirely to certain southern and western States. They are all of approximately the same geologic ages,—Cretaceous or Tertiary,—and are mostly confined to one division of the Cretaceous. The principal chalk or soft limestone deposits available for use in Portland cement manufacture occur in three widely separated areas, occupying respectively (*a*) parts of Alabama and Mississippi; (*b*) parts of Texas and Arkansas; and, (*c*) parts of Iowa, Nebraska, North and South Dakota.

Composition.—In composition these chalks, or "rotten limestones," vary from a rather pure calcium carbonate, low in both magnesia and clayey materials, to an impure clayey limestone, requiring little additional clay to make it fit for use in Portland cement manufacture. Analyses quoted from various authors of a number of these chalky limestones are given in Table IV, and will serve to show their range of composition.

Analyses of Chalky Limestones.

	Demopolis, Ala.	San Antonio, Texas.	Dallas, Texas.	White Cliffs, Ark.	Yankton, S. Dak.	Milton, N. Dak.
Silica	12.13	5.77	23.55	7.97	8.20	9.15
Alumina	4.17					4.80
Iron oxide	3.28	2.12	1.50	1.09	7.07	2.30
Lime carbonate ..	75.07	90.15	70.21	88.64	83.59	63.75
Magnesium carb'te	.92	.15	.58	.73	n.d.	1.25

Fresh-Water Marls.

Marls, in the sense in which the term is used in the Portland cement industry, are incoherent limestones which have been deposited in the basins of existing or extinct lakes. So far as chemical composition is concerned, marls are practically pure limestones, being composed entirely of calcium carbonate. Physically, however, they differ greatly from the compact rocks which are commonly described as limestones, for the marls are granular, incoherent deposits. This curious physical character of marls is due to the conditions under which they have been deposited, and varies somewhat according to the particular conditions which governed their deposition in different localities.

A warning to the reader concerning other uses of the term "marl" may profitably be introduced here. The meaning above given is that in which the term marl is commonly used in the cement industry at the present day. But in geological and agricultural reports, particularly in those issued before the Port-

land cement industry became prominent in this country, the term marl has been used to cover several very different substances. The following three uses of the term will be found particularly common, and must be guarded against when such reports are being examined in search for descriptions of deposits of cement materials.

(1.) In early days the term "marls" and "marlytes" were used to describe deposits of calcareous shales—and often covered shales which were not particularly calcareous. This use of the term will be found in many of the earlier geological reports issued by New York, Ohio, and other interior States.

(2.) In New Jersey and the States southward bordering on the Atlantic and Gulf of Mexico, the term marl is commonly applied to deposits of soft chalky or unconsolidated limestone, often containing considerable clayey and phosphatic matter. These limestones are of marine origin, and not related to the fresh-water marl deposits which are the subject of the present chapter.

(3.) In the same States as are included in the last paragraph, but particularly in New Jersey and Virginia, large deposits of the so-called 'green sand marls" occur. This material is, in no way, related to the true marls (which are essentially lime carbonates), but consists almost entirely of an iron silicate, with very small percentages of clayey, calcareous, and phosphatic matter.

Origin or marls.—The exact cause of the deposition of marls has been the subject of much investigation and discussion, particularly in the past few years, since they have become of economic importance. The reader who wishes to obtain further details concerning this question will do well to refer to the following series of papers.

(1.) Blatchley, W. S., and Ashley, G. H. The Lakes of Northern Indiana, and their associated marl deposits, in 25th Ann. Rept. Indiana Dept. Geology and Natural Resources, pp. 31-321.

(2.) Davis, C. A. A contribution to the natural history of marl. Journal of Geology, Vol. 8, pp. 485-497.

(3.) Davis, C. A. Second contribution to the natural history of marl. Journal of Geology, Vol. 9, pp. 491-506.

(4.) Davis, C. A. A contribution to the natural history of marl. Vol. 8, pt. 3, Reports Michigan Geological Survey, pp. 65-102.

(5.) Lane, A. C. Notes on the origin of Michigan bog limes. Vol. 8, pt. 3, Reports Michigan Geological Survey, pp. 199-223.

Disregarding the points in controversy, which are of no particular practical importance, it may be said that marls are deposited in lakes by spring or stream waters carrying lime carbonate in solution. The actual deposition is in part due to purely physical and chemical causes, and in part to the direct or indirect action of animal or vegetable life. The result, in any case, is that a calcareous deposit forms along the sides and over the bottom of the lake, this deposit consisting of lime carbonate, mostly in a finely granular form, interspersed with shells and shell fragments.

Geographic distribution of marl deposits.—The geographic distribution of marl deposits is intimately related to the geologic history of the region in which they occur. Marl beds are, as indicated in the preceding section, the result of the filling of lake basins. Lakes are not common except in those portions of the United States which were affected by glacial action, since lakes are in general due to the damming of streams by glacial material. Workable marl deposits, therefore, are almost exclusively confined to those portions of the United States and Canada lying north of the former southern limit of the glaciers.

Marl beds are found in the New England States, where they are seldom of important size, and in New York, where large beds occur in the central and western portions of the State. Deposits are frequent and important in Michigan, and in the northern portions of Ohio, Indiana, and Illinois. Marl beds occur in Wisconsin and Minnesota, but have not been as yet exploited for cement manufacture.

Composition.—As shown by the analyses below, marls are usually very pure lime carbonates. They, therefore, require the addition of considerable clay to bring them up to the proper composition for a Portland cement mixture.

The marls are readily excavated, but necessarily carry a large percentage of water. The mixture, on this account, is commonly made in the wet way, which necessitates driving off a high percentage of water in the kilns. Analyses of typical marls and clays are given in the following table.

Analyses of marls and clays used in cement plants.

	Marl.			Clay.		
Silica	0.25	3.0	1.60	40.48	52.0	63.75
Alumina					17.0	16.40
Iron oxide	.10		1.55	20.95	5.0	6.35
Lime carbonate ...	94.39	93.0	88.9	25.80	20.0	4.0
Magnesium carb'te	.38	1.5	.94	.99	....	2.1

Alkali Waste.

A very large amount of waste material results from the process used at alkali works in the manufacture of caustic soda. This waste material is largely a precipitated form of calcium carbonate, and if it is sufficiently free from impurities, it furnishes a cheap source of lime for use in Portland cement manufacture.

The availability of alkali waste for this purpose depends largely on what process was used at the alkali plant. Leblanc process waste, for example, carries a very large percentage of sulphides, which prevents its use as a Portland cement material. Waste resulting from the use of the ammonia process, on the other hand, is usually a very pure mass of lime, mostly in the form of carbonate, though a little lime hydrate is commonly also present. As pyrite is not used in the ammonia process, its waste is usually low enough in sulphur to be used as a cement material. The waste may carry a low or a very high percentage of magnesia, according to the character of the limestone that has been used. When a low-magnesia limestone has been used, the resulting waste is a very satisfactory Portland cement material.

The following analyses are fairly representative of the waste obtained at alkali plants using the ammonia process.

Analyses of alkali waste.

	1	2	3	4
Silica (SiO_2)	0.60	1.75	1.98	0.98
Alumina (Al_2O_3)		0.61	1.41	1.62
Iron oxide (Fe_2O_3)	3.04		1.38	
Lime (CaO)	53.33	50.60	48.29	50.44
Magnesia (MgO)	0.48	5.35	1.51	4.97
Alkalies (Na_2O, K_2O)	0.20	0.64	0.64	0.50
Sulphur trioxide (Co3)	n.d.	n.d.	1.26	n.d.
Sulphur (S)	n.d.	0.10	n.d.	0.06
Carbon dioxide (CO_2)	42.43		39.60	n.d.
Water and organic matter	n.d.	41.70	3.80	n.d.

Of the analyses quoted in the preceding table, those in the first and third columns represent materials which are actually used in Portland cement manufacture in England and the United States. The alkali wastes whose analyses are given in the second and fourth columns are notably too high in magnesia to be advisable for such use.

Blast furnace slag.

True Portland cements, which must be sharply distinguished from the slag (or puzzolan) cements can be made from mixtures which contain blast furnace slag as one ingredient. In this case the slag is intimately mixed with limestone and the mixture is finely powdered. It is then burned in kilns and the resulting clinker pulverized.

The slags from iron furnaces consist essentially of lime (CaO), silica (SiO_2), and alumina (Al_2O_3); though small percentages of iron oxide (FeO), magnesia (MgO), and sulphur (S), are commonly present. Slag may therefore be regarded as a very impure limestone or a very calcareous clay,

The slag used at a German Portland cement plant has the following range in composition.

Analysis of slag used in Portland cement manufacture.

Silicia (SiO_2)	30.	35.
Alumina (Al_2O_3)	10.	14.
Iron oxide (FeO)	0.2	1.2
Lime (CaO)	46.	49.
Magnesia (MgO)	0.5	3.5
Sulphur trioxide (SO_3)	0.2	0.6

Clays and Shales.

Clays are ultimately derived from the decay of older rocks, the finer particles resulting from this decay being carried off and deposited by streams along their channels, in lakes, or along parts of the sea coast or sea bottom as beds of clay. In chemical composition the clays are composed essentially of silica and alumina, though iron oxide is almost invariably present in more or less amount, while lime, magnesia, alkalies and sulphur are of frequent occurrence, though usually only in small percentages.

Shales are clays which have become hardened by pressure. The so-called "fire-clays" of the Coal Measures are shales, as are many of the other "clays" of commerce.

For use as Portland cement materials clays or shales should be as free as possible from gravel and sand, as the silica present as pebbles or grit is practically inert in the kiln unless ground more finely than is economically practicable. In composition they should not carry less than 55 per cent. of silica, and preferably from 60 to 70 per cent. The alumina and iron oxide together should not amount to more than one-half the percentage of silica, and the composition will usually be better the nearer the ratio $Al_2O_3+Fe_2O_3=\frac{SiO_2}{3}$ is approached.

Nodules of lime carbonate, gypsum or pyrite, if present in any quantity, are undesirable; though the lime carbonate is not absolutely injurious. Magnesia and alkalis should be low, preferably not above 3 per cent.

Analyses of clays and shales used in various American Portland cement plants will be found on pages 27 and 30.

Slate.

Slate is, so far as origin is concerned, merely a form of shale in which a fine, even and parallel cleavage has been developed by pressure. In composition, therefore, it will vary exactly as do the shales considered on previous pages, and so far as composition alone is concerned, slate would not be worthy of more attention, as a Portland cement material, than any other shale.

Commercial considerations in connection with the slate industry, however, make slate a very important possible source of cement material. Good roofing slate is a relatively scarce material, and commands a good price when found. In the preparation of roofing slate for the market so much material is lost during sawing, splitting, etc., that only about 10 to 25 per cent. of the amount quarried is salable as slate. The remaining 75 to 90 per cent. is of no service to the slate miner. It is sent to the dump heap, and is a continual source of trouble and expense. This very material, however, as can be seen from the analyses quoted below, is often admirable for use, in connection with limestone, in a Portland cement mixture. As it is a waste product, it could be obtained very cheaply by the cement manufacturer.

Composition of American roofing slates.

	Max.	Average	Min.
Silica (SiO_2)	68.62	60.64	54.05
Alumina (Al_2O_3)	24.71	18.05	9.77
Iron oxides (FeO, Fe_2O_3)	10.66	6.87	2.18
Lime (CaO)	5.23	1.54	....
Magnesia (MgO)	6.43	2.60	0.12
Alkalies (K_2O, Na_2O)	8.68	4.74	1.93
Ferrous sulphide (FeS_2)	....	0.38	....
Carbon dioxide (CO_2)	....	1.47	....
Water of combination	....	3.51	....
Moisture, below 110°C	....	0.62	....

CHAPTER 5.

ECONOMIC CONSIDERATIONS AND METHODS OF MANUFACTURE.

Determining the possible value for Portland cement manufacture of a deposit of raw material is a complex problem, depending upon a number of distinct factors, all of which must be given due consideration. The more important of these factors are:

(1.) Chemical composition of the material.
(2.) Physical character of the material.
(3.) Amount of material available.
(4.) Location of the deposit with respect to transportation routes.
(5.) Location of the deposit with respect to fuel supplies.
(6.) Location of the deposit with respect to markets.

The natural raw materials used at present in Portland cement manufacture are obtained by one of three methods,—(a) quarrying; (b) mining, and (c) dredging. When the cement manufacturer is given an opportunity to choose between these different methods of excavation, his choice will depend partly on the physical character of the material to be excavated and partly on the topographical and geological conditions. Usually, however, there is no opportunity for a choice of methods, for in any given case one of the methods will be so evidently the only possible mode of handling the material as to leave no room for other considerations.

The three different methods of excavation will first be briefly considered, after which the cost of raw materials at the mill will be discussed.

Quarrying.—In the following pages the term "quarrying" will be used to cover all methods of obtaining raw materials from open excavations,—quarries, cuts or pits—whether the material excavated be a limestone, a shale or a clay. Quarrying is the most natural and common method of excavating the

raw materials for cement manufacture. If marl, which is usually worked by dredging, be excluded from consideration, it is probably within safe limits to say that 95 per cent. of the raw materials used at American Portland cement plants are obtained by quarrying. If marls be included, the percentages excavated by different methods would probably be about as follows: Quarrying, 88 per cent.; dredging, 10 per cent.; mining, 2 per cent.

In the majority of limestone quarries the material is blasted out and loaded by hand on to cars or carts. In a few limestone quarries a steam shovel is employed to do the loading, and in shale quarries this use of steam shovels is more frequent. In certain clay and shale pits, where the materials are of suitable character, the steam shovel does all the work, both excavating and loading the raw materials.

The rock is usually shipped to the mill as quarried without any treatment except sledging it to convenient size for loading. At a few quarries, however, a crushing plant is installed at the quarry, and the rock is sent as crushed stone to the mill. A few plants also have installed their driers at the quarry, and dry the stone before shipping it to the mill. Except the saving of mill space thus attained, this practice seems to have little to commend it.

Mining.—The term "mining" will be used, in distinction from "quarrying," to cover methods of obtaining any kind of raw material by underground workings, through shafts or tunnels. Mining is, of course, rarely employed in excavating materials of such low value per ton as the raw materials for Portland cement manufacture. Occasionally, however, when a thin bed of limestone or shale is being worked, its dip will carry it under such a thickness of other strata as to make mining cheaper than stripping and quarrying, for that particular case.

Mining is considerably more expensive work than quarrying, but there are a few advantages about it that serve to counterbalance the greater cost per ton of raw material. A mine can be worked steadily and economically in all kinds of weather, while an open cut or quarry is commonly in a more or less unworkable condition for about three months of the year. Material won by mining is, moreover, always dry and clean.

Dredging.—The term "dredging" will be here used to cover all methods of excavating soft, wet, raw materials. The fact

that the materials are wet implies that the deposit occurs in a basin or depression; and this in turn implies that the mill is probably located at a higher elevation than the deposit of raw material, thus necessitating up-hill transportation to the mill.

The only raw material for Portland cement manufacture that is extensively worked by dredging, in the United States, is marl. Occasionally the clay used is obtained from deposits overlain by more or less water; but this is rarely done except where the marl and clay are interbedded or associated in the same deposit.

A marl deposit, in addition to containing much water diffused throughout its mass, is usually covered by a more or less considerable depth of water. This will frequently require the partial draining of the basin in order to get tracks laid near enough to be of service.

In dredging marl the excavator is frequently mounted on a barge, which floats in a channel resulting from previous investigation. Occasionally, in deposits which either were originally covered by very little water or have been drained, the shovel is mounted on a car, running on tracks laid along the edge of the deposit.

The material brought up by the dredge may be transported to the mill in two different ways, the choice depending largely upon the manufacturing processes in use at the plant. At plants using dome or chamber kilns, or where the marl is to be dried before sending to the kiln, the excavated marl is usually loaded by the shovel on cars, and hauled to the mill by horse or steam power. At normal marl plants, using a very wet mixture, it is probable that the second method of transportation is more economical. This consists of dumping the marl from the excavator into tanks, adding sufficient water to make it flow readily, and pumping the fluid mixture to the mill in pipes.

Cost of raw materials at mill.—The most natural way, perhaps, to express the cost of the raw.material delivered at the mill would be to state it as being so many cents uper ton or cubic yard of raw material; and this is the method followed by quarrymen or miners in general. To the cement manufacturer, however, such an estimate is not so suitable as one based on the cost of raw materials per ton or barrel of finished cement.

In the case of hard and comparatively dry limestones or shales, it may be considered that the raw material loses 33 1-3 per cent.

in weight on burning. Converting this relation into pounds of raw material and of clinker we find that 600 pounds of dry raw material will make about 400 pounds of clinker. Allowing something for other losses in the process of manufacture, it is convenient and sufficiently accurate to estimate that 600 pounds of dry raw material will give one barrel of finished cement. These estimates must be increased if the raw material carry any appreciable amount of water. Clays will frequently contain 15 per cent. or more of water; while soft chalky limestones, if quarried during wet weather, may carry as high as 15 to over 20 per cent. A Portland cement mixture composed of a pure chalky limestone and a clay might, therefore, average 10 to 20 per cent. of water; and consequently about 700 pounds of such a mixture would be required to make one barrel of finished cement.

With marls the loss on drying and burning is much greater. Russell states* that according to determinations made by E. D. natural deposits, contains about 47 1-2 pounds of lime carbonate and 48 pounds of water. In making cement from a mixture of marl and clay, therefore, it would be necessary to figure on excavating and transporting over 1,000 pounds of raw material for every barrel of finished cement.

From the preceding notes it will be understood that the cost of raw materials at the mill, per barrel of cement, will vary not only with the cost of excavation, but with the kind of materials in use.

In dealing with hard dry materials, extracted from open quarries near the mills, the cost of raw materials may vary between 8 cents and 15 cents per barrel of cement. The lower figure named is probably about the lowest attainable with good management and under favorable natural conditions; the higher figure is probably a maximum for fairly careful management of a quarry under eastern labor conditions. When it is necessary to mine the materials, the cost will be somewhat increased. Cement rock has been mined at a cost equivalent to 10 cents per barrel of cement; but the figure is attained under particularly favorable conditions. The cost of mining and transportation may reach from this figure up to 20 cents per barrel.

*22nd Ann. Rept., U. S. Geol. Surv., pt. 3, p. 657.

METHODS OF MANUFACTURE.

If, as in the present volume, we exclude from consideration the so-called "natural Portlands," Portland cement may be regarded as being an artificial product, obtained by burning to semi-fusion an intimate mixture of pulverized materials, this mixture containing lime, silica and alumina, varying in proportion only with certain narrow limits; and by crushing finely the clinker resulting from this burning.

If this restricted definition of Portland cement be accepted, four points may be regarded as being of cardinal importance in its manufacture. These are:

(1) The cement mixture must be of the proper chemical composition.

(2) The materials of which it is composed must be carefully ground and intimately mixed before burning.

(3) The mixture must be burned at the proper temperature.

(4) After burning, the resulting clinker must be finely ground.

The first named of these points—the chemical composition of the mixture—can be more advantageously discussed after the other three points have been disposed of. The subjects will, therefore, be taken up in the following order:

Preparation of the mixture for the kiln.
Burning the mixture.
Grinding the clinker, addition of gypsum, etc.
Composition and properties of Portland cement.

PREPARATION OF THE MIXTURE FOR THE KILN.

The preparation of the mixture for the kiln involves the reduction of both of the raw materials to a very fine powder, and their intimate mixture. In practice the raw materials are usually crushed more or less finely, and then mixed, after which the final reduction to powder takes place. Two general methods of treatment—the dry and the wet—are in use at different plants. Unless the limey constituent of the mixture is a marl, already full of water, the dry method is almost invariably followed. This consists merely in keeping the materials in as dry

a condition as possible throughout the entire process of crushing and mixing; and, if the raw materials originally contained a little moisture, they are dried before being powdered and mixed. In the wet method, on the other hand, the materials are powdered and mixed while in a very fluid state, containing 60 per cent. or more of water.

Drying the Raw Materials.—With the exception of the marls and clays used in the wet method of manufacture, Portland cement materials are usually dried before the grinding is commenced. This is necessary because the raw materials, as they come from the quarry, pit or mine, will almost invariably carry appreciable, though often very small, percentages of water, which greatly reduces the efficiency of most modern types of grinding mills, and tends to clog the discharge screens.

Percentage of Water in Raw Materials.—The percentage of water thus carried by the crude raw material will depend largely on the character of the material; partly on the method of handling and storing it; and partly on weather conditions.

In the case of hard limestones, freshly quarried, the water will commonly range from 1-2 per cent. to 3 per cent., rarely reaching or exceeding the higher figure except in the very wet quarries or during a rainy season. Such limestones, comparatively dry when quarried, are frequently sent to the grinding mills without artificial drying.

With the soft, chalky limestones, which absorb water very rapidly, the percentage can usually be kept down to 5 per cent. or less in dry weather; while prolonged wet weather may necessitate the handling at the mill of material carrying as high as 15 to 20 per cent. of water.

The clays present a much more complicated case. In addition to the hydroscopic or mechanically-held water that they may contain, there is also always present a certain percentage of chemically combined water. The amount of hydroscopic water present will depnd on the treatment and exposure of the clay; and may vary from 1 per cent. or so in clays which have been stored and air-dried to as high as 30 per cent. in fresh clays. The chemically combined water will depend largely on the composition of the clay, and may vary from 5 to 12 per cent. The hygroscopic or mechanically held water of clays can be driven off at a temperature of 212° F., while the chemically

combined water is lost only at a low red heat. The total water, therefore, to be driven off from clays may range from 6 to 42 per cent., depending on the weather, the drainage of the clay pit, and the care taken in preventing unnecessary exposure to moisture of the excavated clay. The average total amount of moisture will probably be about 15 per cent.

In dealing with shales, the mechanically-held water will rarely rise above 10 per cent., and can commonly be kept well below that limit. An additional 2 to 7 per cent. of water will be carried, by any shale, in a state of chemical combination.

At a few plants marl is used, with clay, in a dry process. As noted elsewhere, the marls, as excavated, carry usually about 50 per cent. of water. This case presents a more difficult problem than do the other raw materials, because the vegetable matter usually present in marls is extremely retentive of water.

It will be seen, therefore, that cement materials may carry from 1 per cent. to 50 per cent. of water when they reach the mill. In a dry process it is necessary to remove practically all of this water before commencing the grinding of the materials. One reason for this is that fine pulverizing can not be economically or satisfactorily accomplished unless absolutely dry material is fed to the grinding machinery.

Another reason, which is one of convenience rather than of necessity, is that the presence of water in the raw materials complicates the calculation of the cement mixture.

Methods and cost of drying.—The type of dryer commonly used in cement plants is a cylinder approximately 5 feet in diameter and 40 feet or so in length, set at a slight inclination to the horizontal, and rotating on bearings. The wet raw material is fed in at the upper end of the cylinder, and it moves gradually toward the lower end, under the influence of gravity, as the cylinder revolves. In many dryers angle irons are bolted to the interior in such a way as to lift and drop the raw material alternately, thus exposing it more completely to the action of the heated gases, and materially assisting in the drying process. The dried raw material falls from the lower end of the cylinder into an elevator boot, and is then carried to the grinding mills.

The drying cylinder is heated either by a separate furnace or by waste gases from the cement kiln. In either case the pro-

ducts of combustion are introduced into the cylinder at its lower end, and drawn through it, and escape up a stack set at the upper end of the dryer.

The dryer above described is the simplest, and is most commonly used. For handling the small percentages of water contained in most cement materials it is very efficient, but for dealing with high percentages of water, such as are encountered when marl is to be used in a dry process, it seems probable that double-heating dryers will be found more economical. This type is exemplified by the Ruggles-Coles dryer, in which a double cylinder is employed. The wet raw material is fed into the space between the inner and outer cylinders, while the heated gases pass first through the inner cylinder, and then, in a reverse direction, through the space between the inner and outer cylinders. This double-heating type of dryer is employed in almost all of the slag cement plants in the United States, and is also in use in several Portland cement plants.

When vertical kilns were in use, drying floors and drying tunnels were extensively used, but at present they can be found in only a few places, being everywhere else supplanted by the rotary dryers.

The cost of drying will depend on the cost of fuel, the percentage of water in the wet material and the type of dryer. Even under the most unfavorable conditions five pounds of water can be expected to be evaporated per pound of coal used, while a good dryer will usually evaporate seven or eight pounds of water per pound of coal.

Grinding and Mixing—Dry Methods.—Part at least of the grinding is usually accomplished before the drying, but for convenience the subjects have been separated in the present paper. Usually the limestone is sent through a crusher at the quarry or mill before being dried, and occasionally the raw material is further reduced in a Williams mill, etc., before drying, but the principal part of the reduction always takes place after the material has been dried.

After the two raw materials have been separately dried they may be mixed immediately, or each may be further reduced separately before mixing. Automatic mixers, of which many types are on the market, give a mixture in proportions determined upon from analysis of the materials.

The further reduction of the mixture is usually carried on in two stages, the material being ground to say 30 mesh in a ball mill, komminuter, Griffin mill, etc., and finally reduced in a tube mill. At a few plants, however, single stage reduction is practiced in Griffn or Huntington mills, while at the Edison plant at Stewartsville, N. J., the reduction is accomplished in a series of rolls.

The majority of plants use either the Griffin mill and tube mill or the ball and tube mills, and there is probably little difference in the cost of operating these two combinations. The ball mill has never been quite as much of a success as its companion. the tube mill, and has been replaced at several plants by the komminuter.

FINENESS OF MIXTURE.—After its final reduction, and when ready for burning, the mixture will usually run from 90 to 95 per cent. through a 100-mesh sieve. In the plants of the Lehigh district the mixture is rarely crushed as fine as when limestone and clay are used. Newberry* has pointed out in explanation for this that an argillaceous limestone (cement rock) mixed with a comparatively small quantity of purer limestone. as in the Lehigh plants, requires less thorough mixing and less fine grinding than when a mixture of limestone and clay (or marl and clay) is uesd, for even the coarser particles of the argillaceous limestone will vary so little in chemical composition from the proper mixture as to affect the quality of the resulting cement but little, should either mixing or grinding be incompletely accomplished.

A very good example of typical Lehigh Valley grinding of raw material is afforded by a specimen examined* by Prof. E. D. Campbell. This specimen of raw mix ready for burning was furnished by one of the best of the eastern Pennsylvania cement plants. A mechanical analysis of it showed the following results:

	Mesh of sieve.		
	50	100	200
Per cent. passing	96.9%	85.6%	72.4%
Per cent. residue	3.1%	14.4%	27.6%

The material, therefore, is so coarsely ground that only a trifle over 85 per cent. passes a 100-mesh sieve.

*Twentieth Ann. Rept. U. S. Geol. Surv., Pt. 6, p. 545.
*Journal Amer. Chem. Soc., vol. 25.

Grinding and Mixing—Slag-Limestone Mixtures.—While the manufacture of Portland cement from a mixture of slag and limestone is similar in general theory and practice to its manufacture from a limestone-clay mixture, certain interesting difference occur in the preparation of the mixture. In the following paragraphs the general methods of preparing mixtures of slag and limestone for use in Portland cement manufacture will first be noted, after which certain processes peculiar to the use of this particular mixture will be described separately.

General methods.—After it had been determined that the pozzuolanic cement made* by mixing slag with lime without subsequent burning of the mixture, was not an entirely satisfactory structural material, attention was soon directed toward the problem of making a true Portland cement from such slag. The blast-furnace slags commonly available, while carrying enough silica and alumina for a cement mixture, are too low in lime to be suitable for Portland cement. Additional lime must be added, usually in the form of limestone; the slag and limestone must be well mixed and the mixture properly burned. The general methods for accomplishing the proper mixture of the materials vary in details. It seems probable that the first method used in attempting to make a true Portland cement from slag, was to dump the proper proportion of limestone, broken into small lumps, into molten slag. The idea was that both mixing and calcination could thus be accomplished in one stage; but in practice it was found that the resulting cement was variable in composition and always low in grade. This method has accordingly fallen into disuse, and at present three different general processes of preparing the mixture are practiced at different European and American plants.

1. The slag is granulated, dried, and ground, while the limestone is dried and ground separately. The two materials are then mixed in proper proportions, the mixture is finely pulverized in tube mills, and the product is fed in a powdered state to rotary kilns.

2. The slag is granulated, dried, and mixed with slightly less than the calculated proper amount of limestone, which has been previously dried and powdered. To this mixture is added

*See Municipal Engineering, vol. 24, p. 335, May, 1903.

sufficient powdered slaked lime (say 2 to 6 per cent.) to bring the mixture up to correct composition. The intimate mixture and final reduction are then accomplished in ball and tube mills. About 8 per cent. of water is then added, and the slurry is made into bricks, which are dried and burned in a dome or chamber kiln.

3. Slag is granulated and mixed, while still wet, with crushed limestone in proper proportions. This mixture is run through a rotary calciner, heated by waste kiln gases, in which the temperature is sufficient not only to dry the mixture, but also to partly powder it, and to reduce most of the limestone to quicklime. The mixture is then pulverized and fed into rotary kilns.

Of the three general processes above described, the second is unsuited to American conditions. The first and third are adapted to the use of the rotary kiln. The third seems to be the most economical, and has given remarkably low fuel consumption in practice, but so far has not been taken up in the United States.

Certain points of manufacture peculiar to the use of mixtures of slag and limestone will now be described.

Composition of the slag.—The slags available for use in Portland cement manufacture are of quite common occurrence in iron-producing districts. Those best suited for such use are the more basic blast-furnace slags, and the higher such slags run in lime the more available they are for this use. The slags utilized will generally run from 30 to 40 per cent. lime. The presence of over 3 per cent. or so of magnesia in a slag is of course enough to render its use as a Portland cement material inadvisable; and on this account slags from furnaces using dolomite (magnesian limestone) as a flux, are unsuited for cement manufacture. The presence of any notable percentage of sulphur is also a drawback, though, as will be later noted, part of the sulphur in the slag will be removed during the process of manufacture.

Granulation of slag.—If slag be allowed to cool slowly it solidifies into a dense, tough material, which is not readily reduced to the requisite fineness for a cement mixture. If it be cooled suddenly, however, as by bringing the stream of molten slag into contact with cold water, the slag is "granulated," *i. e.*, it breaks up into small porous particles. This granulated slag or "slag sand" is much more readily pulverized than a slowly

cooled slag; its sudden cooling has also intensified the chemical activity of its constituents so as to give it hydraulic properties, while part of the sulphur contained in the original slag has been removed. The sole disadvantage of the process of granulating slag is that the product contains 20 to 40 per cent. of water, which must be driven off before the granulated slag is sent to the grinding machinery.

In practice the granulation of the slag is effected by directing the stream of molten slag direct from the furnace into a sheet-iron through. A small stream of water flows along this trough, the quantity and rate of flow of the water being regulated so as to give complete granulation of the slag without using an excessive amount of water. The trough may be so directed as to discharge the granulated slag into tanks or into box cars, which are usually perforated at intervals along the sides so as to allow part of the water to drain off.

Drying the slag.—As above noted, the granulated slag may carry from 20 to 40 per cent. of water. This is removed by treating the slag in rotary dryers. In practice such driers give an evaporation of 8 to 10 pounds of water per pound of coal. The practice of slag drying is very fully described in Vol. 10 of the Mineral Industry, pages 84-95, where figures and descriptions of various driers are also given, with data on their evaporative efficiency. As noted earlier in this article, one of the methods of manufacturing Portland cement from slag puts off the drying of the slag until after it has been mixed with the limestone, and then accomplishes the drying by utilizing waste heat from the kilns. Kiln gases could of course be used anyway in the slag driers, but it so happens that they have not been so used except in plants following the method in question.

Grinding the slag.—Slag can be crushed with considerable ease to about 50 mesh, but notwithstanding its apparent brittleness it is difficult to grind it finer. Until the introduction of the tube mill in fact it was almost impossible to reduce this material to the fineness necessary for a cement mixture, and the proper grinding of the slag is still an expensive part of the process, as compared with the grinding of limestone, shales, or clay.

Composition of the limestone.—As the slag carries all the silica and alumina necessary for the cement mixture, the limestone to be added to it should be simply a pure lime carbonate.

The limestone used for flux at the furnace which supplies the slag will usually be found to be of suitable composition for use in making up the cement mixture.

Economics of using slag-limestone mixtures.—The manufacture of a true Portland cement from a mixture of slag and limestone presents certain undoubted advantages over the use of any other raw materials, while it has also a few disadvantages.

Probably the most prominent of the advantages lies in the fact that the most important raw material—the slag—can usually be obtained more cheaply than an equal amount of natural raw material could be quarried or mined. The slag is a waste product, and a troublesome material to dispose of, for which reasons it is obtained at small expense to the cement plant. Another advantage is due to the occurrence of the lime in the slag as oxide, and not as carbonate. The heat necessary to drive off the carbon dioxide from an equivalent mass of limestone is therefore saved when slag forms part of the cement mixture, and very low fuel consumption is obtained when slag-limestone mixture is burned.

Of the disadvantages, the toughness of the slag and the necessity for drying it before grinding are probably the most important. These serve to partly counterbalance the advantages noted above. A third difficulty, which is not always apparent at first, is that of securing a proper supply of suitable slag. Unless the cement plant is closely connected in ownership with the furnaces from which its slag supply is to be obtained, this difficulty may become very serious. In a season when a good iron market exists the furnace manager will naturally give little thought to the question of supplying slag to an independent cement plant.

The advantages of the mixture, however, seem to outweigh its disadvantages, for the manufacture of Portland cement from slag is now a large and growing industry in both Europe and America. Two Portland cement plants using slag and limestone as raw materials have been established for some time in this country, several others are in course of construction at present, and it seems probable that in the near future Alabama will join Illinois and Pennsylvania as an important producer of Portland cement from slag.

Grinding and Mixing—Wet Methods.—Wet methods of preparing Portland cement mixtures date back to the time when millstones and similar crude grinding contrivances were in use. With such imperfect machinery it was almost impossible to grind dry materials fine enough to give a good Portland cement mixture. The advent of good grinding machinery has practically driven out wet methods of manufacture in this country, except in dealing with materials such as marls, which naturally carry a large percentage of water. One or two plants in the United States do, it is true, deliberately add water to a limestone-clay mixture; but the effect of this practice on the cost sheets of these remarkable plants is not encouraging.

In preparing cement mixtures from marl and clay, a few plants dry both materials before mixing. It seems probable that this practice will spread, for the wet method of mixture is inherently expensive. At present, however, almost all marl plants use wet methods of mixing, and it is therefore necessary to give some space to a discussion of such methods.

Certain points regarding the location, physical condition, and chemical composition of the marls and clays used in such mixtures have important effects upon the cost of the wet process. As regards location, considered on a large scale, it must be borne in mind that marl deposits of workable size occur only in the Northern States and in Canada. In consequence the climate is unfavorable to continuous working throughout the year, for the marl is usually covered with water, and in winter it is difficult to secure the material. In a minor sense location is still an important factor, for marl deposits necessarily and invariably are found in depressions; and the mill must, therefore, just as necessarily, be located at a higher level than its source of raw material, which involves increased expense in transporting the raw material to the mill.

Glacial clays, which are usually employed in connection with marl, commonly carry a much larger proportion of sand and pebbles than do the sedimentary clays of more southern regions.

The effect of the water carried by the marl has been noted on an earlier page. The material as excavated will consist approximately of equal weights of lime carbonate and of water. This on the face of it would seem to be bad enough as a business proposition; but we find that in practice more water is often added to permit the marl to be pumped up to the mill.

On the arrival of the raw materials at the mill the clay is often dried, in order to simplify the calculation of the mixture. The reduction of the clay is commonly accomplished in a disintegrator or in edge-runner mills, after which the material is further reduced in a pug mill, sufficient water being here added to enable it to be pumped readily. It is then ready for mixture with the marl, which at some point in its course has been screened to remove stones, wood, etc., so far as possible. The slurry is further ground in pug mills or wet grinding mills of the disk type; while the final reduction takes place commonly in wet tube mills. The slurry, now containing 30 to 40 per cent. of solid matter and 70 to 60 per cent. of water, is pumped into storage tanks, where it is kept in constant agitation to avoid settling. Analyses of the slurry are taken at this point, and the mixture in the tanks is corrected if found to be of unsatisfactory composition. After standardizing, the slurry is pumped into the rotary kilns. Owing to the large percentage of water contained in the slurry the fuel consumption per barrel of finished cement is 30 to 50 per cent. greater, and the output of each kiln correspondingly less than in the case of a dry mixture.

It may be of interest, for comparison with the above description of the wet process with rotary kilns, to insert a description of the semi-wet process as carried on a few years ago at the dome kiln plant of the Empire Portland Cement Company at Warners, N. Y. The plant has been remodeled since that date, but the processes formerly followed are still of interest, as they resulted in a high-grade though expensive product.

At the Empire plant the marl and clay were obtained from a swamp about three-fourths of a mile from the mill. A revolving derrick with clam-shell bucket was employed for excavating the marl, while the clay was dug with shovels. The materials were taken to the works over a private narrow-gauge road, on cars, carrying about three tons each, drawn by a small locomotive. At the mill the cars were hauled up an inclined track, by means of a cable and drum, to the mixing floor.

The clay was dried in three Cummer "Salamander" driers, after which it was allowed to cool, and then carried to the mills. These mills were of the Sturtevant "rock emery" type, and reduced the clay to a fine powder, in which condition it was fed, after being weighed, to the mixer. The marl was weighed and sent directly to the mixer, no preliminary treatment being neces-

sary. The average charge was about 25 per cent. clay and about 75 per cent. marl.

The mixing was carried on in a mixing pan 12 feet in diameter, in which two large rolls, each about 5 feet in diameter, and 16-inch face, ground and mixed the materials thoroughly. The mixture was then sampled and analyzed, after which it was carried by a belt conveyor to two pug mills, where the mixing was completed and the slurry formed into slabs about 3 feet long and 4 to 5 inches in width and height. These on issuing from the pug mill were cut into a number of sections, so as to give bricks about 6 inches by 4 inches by 4 inches in size. The bricks were then placed on slats, which were loaded on rack cars and run into the drying tunnels. The tunnels were heated by waste gases from the kilns and required from twenty-four to thirty-six hours to dry the bricks.

After drying the bricks were fed into dome kilns, twenty of which were in use, being charged with alternate layers of coke and slurry bricks. The coke charge for a kiln was about four or five tons, and this produced 20 to 26 tons of clinker at each burning, thus giving a fuel consumption of about 20 per cent. as compared with the 40 per cent. or so required in the rotary kilns using wet materials. From thirty-six to forty hours were required for burning the charge. After cooling, the clinker was shoveled out, picked over by hand, and reduced in a Blake crusher, Smidth ball mills, and Davidsen tube mills.

Composition of mixture.—The cement mixture ready for burning will commonly contain from 74 to 77.5 per cent. of lime carbonate, or an equivalent proportion of lime oxide. Several analyses of actual cement mixtures are given in the following table. Analysis No. 1, with its relatively high percentage of magnesia, is fairly typical of Lehigh Valley practice. Analyses Nos. 2 and 3 show mixtures low in lime, while analysis No. 4 is probably the best proportioned of the four, especially in regard to the ratio between silica and alumina plus iron. This ratio, for ordinary purposes, should be about 3.-, as the cement becomes quicker setting and lower in ultimate strength as the percentage of alumina increases. If the alumina percentage be carried too high, moreover, the mixture will give a fusible, sticky clinker when burned, causing trouble in the kilns.

Analyses of cement mixtures.

	1	2	3	4
Silica	12.62	13.46	13.85	14.77
Alumina and iron oxide	6.00	?	7.20	4.35
Carbonate of lime	75.46	73.66	73.93	76.84
Magnesia	2.65	?	?	1.74

BURNING THE MIXTURE.

After the cement mixture has been carefully prepared, as described in preceding pages, it must be burned with equal care.

In the early days of the Portland cement industry a simple vertical kiln, much like that used for burning lime and natural cement, was used for burning the Portland cement mixture. These kilns, while fairly efficient so far as fuel consumption was concerned, were expensive in labor, and their daily output was small. In France and Germany they were soon supplanted by improved types, but still stationary and vertical, which gave very much lower fuel consumption. In America, however, where labor is expensive while fuel is comparatively cheap, an entirely different style of kiln has been evolved. This is the rotary kiln. With the exception of a very few of the older plants, which have retained vertical kilns, all American Portland cement plants are now equipped with rotary kilns.

The history of the gradual evolution of the rotary kiln is of great interest, but as the subject can not be taken up here, reference should be made to the papers cited below* in which details, accompanied often by illustrations of early types of rotary kilns are given.

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*Duryee, E., The first manufacture of Portland cement by the direct rotary kiln process. Engineering News, July 26, 1900.

Lesley, R. W., History of the Portland cement industry in the United States. 8 vo. pp. 146, Philadelphia, 1900.

Lewis, F. H., The American rotary kiln process for Portland cement, in The Cement Industry, pp. 188-199, New York, 1900.

Matthey, H., The invention of the new cement burning method. Engineering and Mining Journal, vol. 67, pp. 555, 705; 1899.

Stanger, W. H., and Blount, B., The rotary process of cement manufacture. Proc. Institution Civil Engineers, vol. 145, pp. 44-136; 1901.

Editorial, The influence of the rotary kiln on the development of Portland cement manufacture in America. Engineering News, May 3, 1900.

The design, construction and operation of the vertical stationary kilns of various types is discussed in many reports in Portland cement, the most satisfactory single paper being probably that referred to below*. As the subject is, in America at least, a matter of simply historical interest, no description of these kilns or their operation will be given in the present bulletin.

At present, practice in burning at the different American cement plants is rapidly approaching uniformity, though differences in materials, etc., will always prevent absolute uniformity from being reached. The kiln in which the material is burned is now almost invariably of the rotary type, the rotary process, which is essentially American in its development, being based upon the substitution of machines for hand labor wherever possible. A brief summary of the process will first be given, after which certain subjects of interest will be taken up in more detail.

Summary of burning process.—As at present used, the rotary kiln is a steel cylinder about 6 feet in diameter; its length, for dry materials, is usually 60 or 80 feet, while for wet mixtures an 80-foot, or even longer, kiln is frequently employed.

This cylinder is set in a slightly inclined position, the inclination being approximately one-half inch to the foot. The kiln is lined, except near the upper end, with very resistant fire brick, to withstand both the high temperature to which its inner surface is subjected and also the destructive action of the molten clinker.

The cement mixture is fed in at the upper end of the kiln, while fuel (which may be either powdered coal, oil, or gas), is injected at its lower end. The kiln, which rests upon geared bearings, is slowly revolved about its axis. This revolution, in connection with the inclination at which the cylinder is set, gradually carries the cement mixture to the lower end of the kiln. In the course of this journey the intense heat generated by the burning fuel first drives off the water and carbon dioxide from the mixture, and then causes the lime, silica, alumina, and

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***Stanger, W. H., and Blount, B., Gilbert, W., and Candlot, E., (Discussion of the value, design and results obtained from various types of fixed kilns). Proc. Institution Civil Engineers, vol. 145, pp. 44, 48, 81, 82, 99, 100; 1901.**

iron to combine chemically to form the partially fused mass known as "cement clinker." This clinker drops out of the lower end of the kiln, is cooled so as to prevent injury to the grinding machinery, and is then sent to the grinding mills.

Theoretical fuel requirements.—As a preliminary to a discussion of actual practice in the matter of fuel, it will be of interest to determine the heat units and fuel theoretically required in the manufacture of Portland cement from a dry mixture of normal composition.

In burning such a mixture to a clinker, practically all of the heat consumed in the operation will be that required for the dissociation of the lime carbonate present into lime oxide and carbon dioxide. Driving off the water of combination that is chemically held by the clay or shale, and decomposing any calcium sulphate (gypsum) that may be present in the raw materials, will require a small additional amount of heat. The amount required for these purposes is not accurately known, however, but is probably so small that it will be more or less entirely offset by the heat which will be liberated during the combination of the lime with the silica and alumina. We may, therefore, without sensible error, regard the total heat theoretically required for the production of a barrel of Portland cement as being that which is necessary for the dissociation of 450 pounds of lime carbonate. With coal of a thermal value of 13,500 B. T. U., burned with only the air supply demanded by theory, this dissociation will require 25½ pounds of coal per barrel of cement, a fuel consumption of only 6.6 per cent.

Losses of heat in practice.—In practice with the rotary kiln, however, there are a number of distinct sources of loss of heat, which result in a fuel consumption immensely greater than the theoretical requirements given above. The more important of these sources of loss are the following:

1. The kiln gases are discharged at a temperature much above that of the atmosphere, ranging from 300°F. to 2,000°F., according to the type of materials used and the length of the kiln.

2. The clinker is discharged at a temperature varying from 300°F. to 2,500°F., the range depending, as before, on materials and length of the kiln.

3. The air supply injected into the kiln is always greater, and usually very much greater, than that required for the perfect combusion of the fuel; and the available heating power of the fuel is thereby reduced.

4. Heat is lost by radiation from the ends and exposed surfaces of the kiln.

5. The mixture, in plants using a wet process, carries a high percentage of water, which must be driven off.

It is evident, therefore, that present-day working conditions serve to increase greatly the amount of fuel actually necessary for the production of a barrel of cement above that required by theory.

Actual fuel requirements and output.—Rotary kilns are nominally rated at a production of 200 barrels per day per kiln. Even on dry and easily clinkered materials and with good coal, however, such an output is not commonly attained with a 60-foot kiln, except in the Lehigh district. Normally a kiln working on a dry mixture will produce from 160 to 180 barrels of cement per day of twenty-four hours. In doing this, if good coal is used, its fuel consumption will commonly be from 120 to 140 pounds of coal per barrel of cement, though it may range as high as 160 pounds, and, on the other hand, has fallen as low as 90 pounds. An output of 175 barrels per day, with a coal consumption of 130 pounds per barrel, may therefore be considered as representing the results of fairly good practice on dry materials with a 60-foot kiln. In dealing with a wet mixture, which may carry anywhere from 30 to 70 per cent. of water, the results are more variable, though always worse than with dry materials. In working a 60-foot kiln on wet material, the output may range from 80 to 120 barrels per day, with a fuel consumption of from 150 to 230 pounds per barrel. Using a longer kiln, partly drying the mixture, and utilizing waste heat, will of course improve these figures materially.

When the heavy Western oils are used for kiln fuel, it may be considered that one gallon of oil is equivalent in the kiln to about ten pounds of coal. The fuel consumption, using dry materials, will range between 11 and 14 gallons of oil per barrel of cement; but the output per day is always somewhat less with oil fuel than where coal is used.

Natural gas in the kiln may be compared with good Pennsylvania coal by allowing about 20,000 to 30,000 cubic feet of gas

as equivalent to a ton of coal. This estimate is, however, based upon too little data to be as close as those above given for oil or coal.

Effect of composition on burning.—The differences in composition between Portland cement mixtures are very slight if compared, for example, to the differences between various natural cement rocks. But even such slight differences as do exist exercise a very appreciable effect on the burning of the mixture. Other things being equal, any increase in the percentage of lime in the mixture will necessitate a higher temperature in order to get an equally sound cement. A mixture which will give a cement carrying 59 per cent. of lime, for example, will require much less thorough burning than would a mixture designed to give a cement with 64 per cent. of lime.

With equal lime percentages, the cement carrying high silica and low alumina and iron will require a higher temperature than if it were lower in silica and higher in alumina and iron. But, on the other hand, if the alumina and iron are carried too high, the clinker will ball up in the kiln, forming sticky and unmanageable masses.

Character of kiln coal.—The fuel most commonly used in modern rotary kiln practice is bituminous coal, pulverized very finely. Coal for this purpose should be high in volatile matter, and as low in ash and sulphur as possible. Russell gives the following analyses of West Virginia and Pennsylvania coals used at present at various cement plants in Michigan.

Analyses of kiln coals.

	1	2	3	4
Fixed carbon	56.15	56.33	55.82	51.69
Volatile matter	35.41	35.26	39.37	39.52
Ash	6.36	7.06	3.81	6.13
Moisture	2.08	1.35	1.00	1.40
Sulphur	1.30	1.34	0.42	1.46

The coal as usually bought is either "slack" or "run of mine." In the latter case it is necessary to crush the lumps before proceeding further with the preparation of the coal, but with slack this preliminary crushing is not necessary, and the material can go directly to the dryer.

Drying coal.—Coal as bought may carry as high as 15 per cent. of water in winter or wet season. Usually it will run from 3 to 8 per cent. To secure good results from the crushing machinery it is necessary that this water should be driven off. For coal drying, as for the drying of raw materials, the rotary dryer seems best adapted to American conditions. It should be said, however, that in drying coal it is usually considered inadvisable to allow the products of combustion to pass through the cylinder in which the coal is being dried. This restriction serves to decrease slightly the possible economy of the dryer, but an evaporation of 6 to 8 pounds of water per pound of fuel coal can still be counted on with any good dryer. The fuel cost of drying coal containing 8 per cent. of moisture, allowing $2 per ton for the coal used as fuel, will therefore be about 3 to 4 cents per ton of dried product.

Pulverizing coal.—Though apparently brittle enough when in large lumps, coal is a difficult material to pulverize finely. For cement kiln use, the fineness of reduction is very variable. The finer the coal is pulverized the better results will be obtained from it in the kiln; and the poorer the quality of the coal the finer it is necessary to pulverize it. The fineness attained may therefore vary from 85 per cent. through a 100-mesh sieve, to 95 per cent. or more, through the same. At one plant a very poor but cheap coal is pulverized to pass 98 per cent. through a 100-mesh sieve, and in consequence gives very good results in the kiln.

Coal pulverizing is usually carried on in two stages, the material being first crushed to 20 to 30 mesh in a Williams mill or ball mill, and finally reduced in a tube mill. At many plants, however, the entire reduction takes place in one stage, Griffin or Huntington mills being used.

Total cost of coal production.—The total cost of crushing (if necessary), drying and pulverizing coal, and of conveying and feeding the product to the kiln, together with fair allowance for replacements and repairs, and for interest on the plant, will probably range from about 20 to 30 cents per ton of dried coal, for a 4-kiln plant. This will be equivalent to a cost of from 3 to 5 cents per barrel of cement. While this may seem a heavy addition to the cost of cement manufacture, it should be remembered that careful drying and fine pulverizing enable the manu-

facturer to use much poorer—and therefore cheaper—grades of coal than could otherwise be utilized.

CLINKER GRINDING. GYPSUM.

Clinker grinding.—The power and machinery required for pulverizing the clinker at a Portland cement plant using the dry process of manufacture is very closely the same as that required for pulverizing the raw materials for the same output. This may seem, at first sight, improbable, for Portland cement clinker is much harder to grind than any possible combination of raw materials; but it must be remembered that for every barrel of cement produced about 600 pounds of raw materials must be pulverized, while only a scant 400 pounds of clinker will be treated, and that the large crushers required for some raw materials can be dispensed with in crushing clinker. With this exception, the raw material side and the clinker side of a dry-process Portland cement plant are usually almost or exactly duplicates.

The difficulty, and in consequence the expense, of grinding clinker will depend in large part on the chemical composition of the clinker and on the temperature at which it has been burned. The difficulty of grinding, for example, increases with the percentage of lime carried by the clinker; and a clinker containing 64 per cent. of lime will be very noticeably more resistant to pulverizing than one carrying 62 per cent. of lime. So far as regards burning, it may be said in general, that the more thoroughly burned the clinker the more difficult it will be to grind, assuming that its chemical composition remains the same.

The tendency among engineers at present is to demand more finely ground cement. While this demand is doubtless justified by the results of comparative tests of finely and coarsely ground cements, it must be borne in mind that any increase in fineness of grinding means a decrease in the product per hour of the grinding mills employed, and a consequent increase in the cost of cement. At some point in the process, therefore, the gain in strength due to fineness of grinding will be counterbalanced by the increased cost of manufacturing the more finely ground product.

The increase in the required fineness has been gradual but steady during recent years. Most specifications now require at

least 90 per cent. to pass a 100-mesh sieve; a number require 92 per cent.; while a few important specifications require 95 per cent. Within a few years it is probable that almost all specifications will go as high as this.

Addition of gypsum.—The cement produced by the rotary kiln is invariably naturally so quick-setting as to require the addition of sulphate of lime. This substance, when added in quantities up to 2½ or 3 per cent., retards the rate of set of the cement proportionately, and appears to exert no injurious influence on the strength of the cement. In amount over 3 per cent., however, its retarding influence seems to become at least doubtful, while a decided weakening of the cement is noticeable.

Sulphate of lime may be added in one of two forms: either as crude gypsum or as burned plaster. Crude gypsum is a natural hydrous lime sulphate, containing about 80 per cent. of lime sulphate and 20 per cent. of water. When gypsum is calcined at temperatures not exceeding 400°F., most of its contained water is driven off. The "plaster" remaining carries about 93 per cent. of lime sulphate, with only 7 per cent of water.

In Portland cement manufacture either gypsum or burned plaster may be used to retard the set of the cement. As a matter of fact, gypsum is the form almost universally employed in the United States. This is merely a question of cost. It is true that to secure the same amount of retardation of set it will be necessary to add a little more of gypsum than if burned plaster were used; but, on the other hand, gypsum is much cheaper than burned plaster.

The addition of the gypsum to the clinker is usually made before it has passed into the ball mill, komminuter, or whatever mill is in use for preliminary grinding. Adding it at this point secures much more thorough mixing and pulverizing than if the mixture were made later in the process. At some of the few plants which use plaster instead of gypsum, the finely ground plaster is not added until the clinker has received the final grinding and is ready for storage or packing.

CONSTITUTION OF PORTLAND CEMENT.

During recent years much attention has been paid by various investigators to the constitution of Portland cement. The chemical composition of any particular sample can, of course, be

readily determined by analysis; and by comparison of a number of such analyses, general statements can be framed as to the range in composition of good Portland cements.

The chemical analyses will determine what ingredients are present, and in what percentages, but other methods of investigation are necessary to ascertain in what manner these various ingredients are combined. A summary of the more important results brought out by these investigations on the constitution of Portland cement is here given.

It would seem to be firmly established that, in a well-burned Portland cement, much of the lime is combined with most of the silica to form the compound 3 CaO, SiO_2,—tricalcic silicate. To this compound is ascribed, in large measure, the hydraulic properties of the cement; and in general it may be said that the value of a Portland cement increases directly as the proportion of 3 CaO, SiO_2. The ideal Portland cement, toward which cements as actually made tend in composition, would consist exclusively of tricalcic silicate, and would be therefore composed entirely of lime and silica in the following proportions:

Lime (CaO)	73.6
Silica (SiO_2)	26.4

Such an ideal cement, however, can not be manufactured under present commercial conditions, for the heat required to clinker such a mixture can not be attained in any working kiln. Newberry has prepared such mixtures by using the oxy-hydrogen blowpipe; and the electrical furnace will also give clinker of this composition; but a pure lime-silica Portland is not possible under present-day conditions.

In order to prepare Portland cement in actual practice, therefore, it is necessary that some other ingredient or ingredients should be present to serve as a flux in aiding the combination of the lime and silica, and such aid is afforded by the presence of alumina and iron oxide.

Alumina (Al_2O_3) and iron oxide (Fe_2O_3), when present in noticeable percentages, serve to reduce the temperature at which combination of the lime and silica (to form 3 CaO, SiO_2) takes place; and this clinkering temperature becomes further and further lowered as the percentages of alumina and iron are increased. The strength and value of the product, however, also decrease as the alumina and iron increase; so that in actual

practice it is necessary to strike a balance between the advantage of low clinkering temperature and the disadvantage of weak cement, and to thus determine how much alumina and iron should be used in the mixture.

It is generally considered that whatever alumina is present in the cement is combined with part of the lime to form the compound 2 CaA, SiO_2,—dicalcic aluminate. It is also held by some, but this fact is somewhat less firmly established than the last, that the iron present is combined with the lime to form the compound 2 CaO, Fe_2O_3. For the purposes of the present paper, it will be sufficient to say that, in the relatively small percentages in which iron occurs in Portland cement, it may for convenience be considered as almost equivalent to alumina and its action, and the two may be calculated together.

PART II.

THE CEMENT RESOURCES OF ALABAMA.

BY EUGENE A. SMITH.

In Alabama is found an extensive series of limestones capable of furnishing excellent raw material for the manufacture of Portland cement, while the shales and clays necessary to complete the mixture are found in every county in the State. As a matter of convenience, the Portland cement materials of northern Alabama and of central and southern Alabama will be discussed separately, because there is a marked geologic as well as geographic distinction between the two portions of the State.

CHAPTER 1.

THE PORTLAND CEMENT MATERIALS OF NORTHERN ALABAMA.

The raw materials for the manufacture of Portland cement occurring in the Paleozoic formations of northern Alabama are limestones, shales, and clays. Of these the limestones belong mainly to the Lower Carboniferous and the Trenton formations; the shales to the Coal Measures, and the clays to the Cambrian, Lower Carboniferous, and Coal Measures. Although as yet these materials have not been utilized for this purpose in Alabama, they have been so used in other States, and there is no reason to doubt that the future will witness their utilization in Alabama.

AVAILABLE LIMESTONES.

General geology.—In northern Alabama the combined effects of geologic structure and erosion have resulted in certain definite topographic types, with which the geologic outcrops are closely connected.

Structurally northern Alabama is made up of a series of parallel synclines and anticlines, trending usually a little north of east. The anticlines are sharp, narrow folds; the synclines are flat, wide basins. The effect of erosion has been to cut away the anticlines and the streams of the region now run along anticlinal valleys bordered by flat-topped synclinal plateaus.

The plateaus throughout most of northern Alabama are capped by conglomerates, shales, and sandstones of the Coal Measures. The lower Carboniferous limestones commonly outcrop along the sides and at the immediate base of the plateaus. The lower Silurian beds occur as long, narrow outcrops in the valleys. The middle of the valley is usually occupied by Cambrian shales and the Knox dolomite. The Trenton limestones would normally outcrop as two parallel bands in each valley—between the middle of the valley and the foothills of the plateaus. Faulting has, however, been so common that only one of these bands is usually present, the other being cut out by a fault.

Lower Carboniferous.—Limestones of suitable quality for cement manufacture occur in the Mountain limestone or Chester formation of the lower Carboniferous. Perhaps the most accessible occurrences of this rock are in the Tennessee Valley to the west of Tuscumbia and south of the river and railroad. Here the quarries of Fossick & Co. were formerly located. Their quarries at this time are farther eastward, but at a greater distance from the river, in Lawrence county north of Russellville. This outcrop extends thence eastward along the base of Little Mountain as far as Whitesburg, above which place to Guntersville the river flows through a valley floored with lower Carboniferous limestone. The Southern Railway passes over outcrops of this rock in most of the mountain coves east of Huntsville, and from Scottsboro to the Tennessee line the country rock is almost entirely of this formation. The Louisville and Nashville Railroad south of Decatur nearly to Wilhite is mostly in the same formation. These two lines, together

with the Tennessee river, would provide ample means of transportation for the rock or for the finished product. Analysis of the rock from the Fossick quarries is given in Table A.

In Browns Valley south of Brooksville the Mountain limestone is the prevailing rock across the valley, and at Bangor and Blount Springs, on the Louisville and Nashville Railroad, there are extensive quarries which have been worked for many years to supply rock for fluxing purposes to the furnaces of the Birmingham district. Analyses Nos. 2, 3, 4, 5, 6, 7, 8, and 9, Table A, show the composition of average samples from these quarries; 5 to 9, inclusive, are of carload samples.

From Brooksville to the Tennessee line a great thickness of this limestone is exposed along the western escarpment of Sand Mountain, below the sandstones of the Coal Measures, which there cap the mountain. In this area the river runs near the foot of the mountain and would afford the means of transportation.

In similar manner the lower Carboniferous limestone outcrops along the western flank of Lookout Mountain in Little Wills Valley, from near Attalla to the Georgia line, and south of Attalla it forms the lower part of the escarpments of Blount and Chandlers Mountains. The Alabama Great Southern Railroad passes very near to the outcrop from the Georgia line down to Springville, Ala. South of Springville large outcrops occur in Shades Valley, and at Trussville are quarries which have supplied the Birmingham furnaces. Analyses 10 to 17, inclusive, Table A, are of material from Trussville; and analyses 12 to 17, inclusive, represent average samples from carload lots delivered to the furnace.

In Murphrees Valley the main outcrop of this rock is on the western side, and quarries at Compton have for many years been worked to supply the Birmingham furnaces. Analyses 18, 19, and 20, Table A, of the rock from these quarries show somewhat varying composition, but by proper selection suitable material could be easily obtained.

In the valleys lying east of Shades Valley and in parts of Shades Valley itself this formation becomes one of prevailing shales and sandstones and the limestones are of limited occurrence and of inferior quality.

Trenton limestone.—The Trenton limestone outcrops in Alabama in three principle areas. In the Tennessee River Valley

some of the smaller streams which flow into the river from the north, like Flint River, Limestone Creek, Elk River, Bluewater Creek, and Shoal Creek, have eroded their valleys into the Trenton limestone. These areas are crossed at only a few points by the railroads leading out from Huntsville and Florence, and no commercial use has yet been made of the rock.

In the narrow anticlinal valleys below enumerated erosion has in most cases sunk the floors of the valleys into Cambrian strata, and, as a consequence, the Trenton limestone occupies a narrow belt on each side, near the base of the Red Mountain ridges. But since a fault usually occurs on one side of these valleys, the Red Mountain ridges and the accompanying Trenton limestone are more fully represented on the unfaulted side, which is the eastern side in all except Murphrees Valley. While the Trenton forms practically a continuous belt along the undisturbed side, extensive areas are sometimes found on the faulted side also. This is the case, for instance, at Vance, on the Alabama Great Southern Railroad, where the rock is quarried for flux for the furnace of the Central Iron Company at Tuscaloosa. Analysis 1 of Table B, shows its composition here. Other series of analyses from lower ledges in the quarry show only 1.22 per cent of silica, but more magnesia.

In cases where erosion has not gone so deep as to reach the Cambrian the Trenton may be found extending entirely across the valleys. This is the case in the lower part of Browns Valley from Brooksville to beyond Guntersville. Above Guntersville the Trenton is seen mainly on the eastern side of the valley. The river touches these outcrops at many points, and at Guntersville the railroad connecting that city with Attalla would afford an additional means of transportation. No developments have yet been made in this area.

The valley separating the Warrior from the Cahaba coal field is known as Roups Valley in the southern and as Jones Valley in the northern part. In these the Trenton occupies a narrow, continuous belt, usually near the base of the eastern Red Mountain ridge, though in places it is high up on the ridge and even at its summit, as at Gate City, where the quarries of the Sloss Iron Company are located. Many analyses of the rock from these quarries have been made, and several are given in Table B, (Nos, 2, 3, 4, 5, 6).

In Murphrees Valley the continuous belt of the Trenton, as above explained, is on the western side, while the faulted remnants are on the eastern side. No quarries have been opened in the Trenton limestone here, but the Louisville and Nashville Railroad goes up the valley as far as Oneonta and would afford means of transportation.

In the Cahaba Valley, which separates the Cahaba coal field from the Coosa coal field, the Trenton is well exposed on the eastern side for the entire length of the valley from Gadsden down. It expands into wide areas near the southern end, where it has been quarried for lime burning, at Pelham, Siluria, Longview, Calera, and other places on the line of the Louisville and Nashville road. Analyses 7, 8 and 9 of Table B, show the composition of the rock in this region.

The Central of Georgia and the Southern railroads cross this belt about midway of its length at Leeds, in Jefferson County, and near its northern end it is crossed by the Louisville and Nashville Railroad, where a quarry at Rock Springs, on the flank of Colvin Mountain, supplies the rock for lime burning. Anaylsis 10 shows the character of the rock at this point.

At Pratts Ferry, on the Cahaba River, a few miles above Centreville, in Bibb County, the Trenton limestone makes high bluffs along the river for several miles, and is in most convenient position for easy quarrying.

Marble works have in former days been established here and should be again put in operation, since the marble is of fine quality and beautifully variegated. No analyses are available, but there is no doubt that much of the rock is sufficiently low in magnesia to be fit for use in cement making. Cahaba River and a short spur from the Mobile and Ohio Railroad would afford transportation facilities for this deposit.

In Big Wills Valley, which separates Sand and Lookout mountains, the Trenton limestone occupies perhaps 25 square miles, but it is crossed only by the railroad connecting Gadsden with Guntersvlile. No anaylses are available.

In the great Coosa Valley region the Trenton outcrops are found mostly on the western border near the base of Lookout Mountain, as in Broomtown Valley, and in other valleys extending south toward Gadsden. While these belts have been utilized in the past for the old Gaylesville, Cornwall, and Round

Mountain furnaces, and possibly for some furnaces now in blast, no analyses are available.

Similarly, farther south, along this western border of the Coosa Valley, and running parallel with the Coosa coal field in Calhoun, St. Clair, and Shelby counties, there are numerous long narrow outcrops of Trenton limestone. The Calcis quarry of the Tennessee Coal, Iron and Railroad Company, on the Central of Georgia Railroad, near Sterritt, is upon one of these outcrops, and furnishes limestone with a very low and uniform percentage of silica and magnesia. Analyses 11, 12, 13, 14, 15, and 16 exhibit the quality of the rock as received at the Ensley Steel Works, but care is taken at the quarry to select ledges low in silica and magnesia, and the analyses therefore represent only the selected ledges and not the average run of the quarry as a whole.

Near Talladega Springs, Marble Valley, and Shelby are other occurrences of the rock, and a quarry a few miles east of Shelby furnace has for many years supplied that furnace with its flux. The quality of the material here is shown by analyses 17, 18, 19, and 20, Table B.

The Cambrian limestones contain generally a very considerable proportion of magnesia, and for this reason are not suited for Portland-cement manufacture, though admirably adapted for furnace stone.

Marbles.—Along the eastern border of the Coosa Valley, near its contact with the metamorphic rocks, there is a belt of limestone which, in places, is a white crystalline marble of great purity, as is shown by analyses 1 to 7, inclusive, of Table C. The Louisville and Nashville Railroad, from Calera to Talladega, passes close to this belt at many points. This marble has been quarried at several places for ornamental stone. It is mentioned here because it is near the railroad and completes the account of the limestone.

THE CLAYS.

The most important clays in the Paleozoic region occur in the Coal Measures, in the Lower Carboniferous, and in the Lower Silurian and Cambrian formations. But, inasmuch as a later formation—the Tuscaloosa of the Cretaceous—borders the Paleozoic on the west and south, and as it contains a great vari-

ety as well as abundance of clays, we shall include it here, although it is not one of the Paleozoics.

Coal Measures.—In this group are numerous beds of shale which have been utilized in the manufacture of vitrified brick and fire brick, but many of them will probably be adapted to cement making. A great body of these shales occurs in connection with the coal seams of the Horse Creek or Mary Lee group, in Jefferson and Walker counties, and in position where they are conventienly situated with reference to limestone and coal and also to transportation lines. They are therefore well worth the attention of those contemplating the location of cement plants.

On the property of Mr. W. H. Graves, near North Birmingham, overlying the coal seam mined by him, there are two beds of shale—one yellowish, the other gray. These two shales have been tested and analyzed, and their composition is shown in Nos. 1 and 2 of the Table D.

Similar shales are known to occur at Coaldale, in Jefferson County, at Pearce's Mills in Marion, and at Cedar Grove Coal Mines in Tuscaloosa. The Coaldale shale is manufactured into vitrified brick. The other two have not yet been utilized.

Analyses 3 and 4 of Table D will show the composition of the shales at Coaldale and Cedar Grove.

It may be of interest to note that Cedar Grove is, so far as yet known, the nearest place to the Gulf ports, where the three essentials in the manufacture of Portland cement, viz., limestone, shale and coal, occur together, and on a railroad.

So also most of the coal seams mined in Alabama rest upon clay beds which have not as yet been specially examined as to their fitness for cement making; but, in view of the proximity of the coal mines to the limestones, it might be worth while to investigate these underclays of the coal seams.

Lower Carboniferous.—Associated with the cherty limestones of the lowermost division of the Lower Carboniferous of some of the anticlinal valleys are beds of clay of excellent quality, much of it being of the nature of china clay.

Probably the best of the exposures of these clays are to be seen in Little Wills Valley, between Fort Payne and the Georgia border, and on the line of the Great Southern Railroad, where for many years quarries have been in operation in sup-

plying the material for tile works and potteries. The clays lie near the base of the formation close above the black shale of the Devonian, and average about 40 feet in thickness, though in places they reach 200 feet. The clay beds alternate with seams of chert which are from 2 to 8 inches in thickness, while the clay beds vary from 12 to 18 inches. The upper half of the clay is more gritty than the lower half which often contains material suitable for the manufacture of the finer grades of porcelain ware. Analyses 5 to 8, in Table D, show the composition of several varieties of clay from this section.

Lower Silurian and Cambrian.—Associated with the cherty limestones and brown iron-ore beds of the formations above named—beds of fine white clay, much of it china clay—are not uncommon. Analysis 9 of the table shows the composition of a white clay from the brown ore bank at Rock Run, in Cherokee County, where the clay is about 30 feet in thickness. Analyses 10 and 11 are also from Rock Run. No. 12, from near Gadsden, No. 13, from Blount County, and No. 14 from Oxanna, in Calhoun County, are clays which seem to be adapted to cement making. While no great number of the clays of these formations have been analyzed, they are known to be widely distributed in Calhoun, Talladega, Jefferson, Tuscaloosa, and other counties in connection with the brown ore deposits.

Cretaceous.—In many respects the most important formation of Alabama, in respect of its clays, is the lowermost division of the Cretaceous, which has been called the Tuscaloosa, and which is in part at least of the same geologic horizon as that of the Raritan clays of New Jersey. The prevailing strata of this formation are yellowish and grayish sands, but subordinated to them are great lenses of massive clay varying in quality from almost pure-white burning clay to dark-purple and mottled varieties high in iron.

The formation occupies a belt of country extending from the north-western corner of the State, around the edges of the Paleozoic formations to the Georgia line at Columbus. Its greatest width is at the northwest boundary of the State where it covers an area 30 or 40 miles wide in Alabama, and of about the same width in Mississippi. The breadth at Wetumpka and thence eastward to the Georgia line is only a few miles. The most important part of this belt is where it is widest in Elmore,

Bibb, Tuscaloosa, Pickens, Fayette, Marion, Lamar, Franklin, and Colbert counties, and the deposits are traversed by the lines of the Mobile and Ohio; the Alabama Great Southern; the Louisville and Nashville; the Southern; and the Kansas City, Memphis and Birmingham railroads; as well as by the Warrior and Tombigbee rivers.

These clays have been described in some detail, and many analyses and physical tests have been presented in the Bulletin No. 6 of the Alabama Geological Survey. From this bulletin have been selected the analyses which appear to indicate the fitness of the clays for cement making.

In Elmore county, in the vicinity of Coosada, along the banks of the river, about Robinson Springs, Edgewood, and Chalk Bluff, there are many occurrences of these clays, some of which have been used in potteries for many years. Analyses 15, from Coosada; 16, from Edgewood; and 17, from Chalk Bluff, are given in the table D.

In Bibb county the clay has been quarried very extensively at Bibbville and near Woodstock for making fire brick. For this purpose the material is carried to Bessemer by the Alabama Great Southern Railroad. No. 18, from Woodstock; and 19, from Bibbville, will represent the average quality of the clay from these beds, which are very extensive, both in thickness and in superficial distribution. The Mobile & Ohio crosses other extensive deposits in the southern part of the county, but no analyses are available.

The most important of the clay beds in Tuscaloosa county are traversed by the Mobile & Ohio Railroad and by the Alabama Great Southern.

Analysis 20, from Hull's; and analysis 21, from the Cribbs beds, are on the Alabama Great Southern; and 22 and 23 are from cuts of the Mobile & Ohio, a few miles west of the city of Tuscaloosa.

Many large beds are exposed along the Mobile & Ohio road in Pickens county also, but very few have been as yet investigated. No. 24 is from Roberts Mill, in this county.

In Lamar and Fayette counties the same conditions prevail as in Pickens and Tuscaloosa. Analysis 25 is of pottery clay from the Cribbs place, in Lamar; and No. 26 is of clay from Wiggins's, 4 miles west of Fayette; and 27 and 28 are clays from W. Doty's place, 14 miles west of that town, in Fayette county.

Marion is one of the banner counties of the State for fine clays, but it is touched by railroads only along its southern border and in the extreme northeastern corner. Although at present not available because inaccessible, the clays mentioned below are worth consideration: No. 29, from Glen Allen; No. 30, from Briggs Fredericks', in Sec. 8, T. 10, R. 13 W. This is from the great clay deposit which gives the name to Chalk Bluff and which underlies about two townships. No. 31 is from a locality about 16 miles southwest of Hamilton, the county seat.

No. 32 is from a locality near the Mississippi line, in section 20, T. 8, R. 15 W., in Franklin county, from land of Mr. Thomas Rollins.

Of the numerous fine clays of Colbert county analyses are given of two from Pegram station, on the Southern Railway, near the Mississippi State line. These are Nos. 33 and 34.

Table A.

Analyses of Lower Carboniferous Limestones.

Number.	1	2	3	4	5	6	7	8	9	10
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	0.50	1.73	0.77	1.14	1.02	1.40	0.68	0.81	0.82	2.16
Iron and aluminum oxide	1.45	.78	.35	.34	1.38	1.17	1.02	.89	.60	2.31
Calcium carb'te.	96.58	96.54	97.60	98.53	95.25	94.67	96.54	97.45	97.37	89.15
Magnesium carbt	2.58	......	......	......	1.73	2.26	1.26	.35	.75	4.20
Sulphur	......	......	......	......	......	......	......	......	.029	......
Number.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	3.12	0.85	1.08	0.73	0.64	1.12	0.42	2.05	4.45	2.80
Iron and aluminum oxide	2.32	.65	.61	.65	.62	.90	.37	.76	3.30	.70
Calcium carb'te.	85.87	93.64	96.91	97.60	97.48	96.38	97.32	89.64	86.35	94.59
Magnesium carbt	4.20	1.36	.90	.52	.76	1.10	1.39	8.15	......	......
Sulphur	......	.024	.019	.018	......	......	.020	......	......	......

1. Average sample from Fossick quarry, near Rockwood, Franklin County. Government Arsenal, Watertown, N. Y., analyst.

2. Average sample from Blount Springs quarry—a compact limestone. Henry McCalley, analyst.

3. Average sample from Blount Springs quarry—a granular oolitic limestone. Henry McCalley, analyst.

4. Average sample upper 75 feet, Blount Springs quarry. J. L. Beeson, analyst.

5-9. Average sample Blount Springs quarry. J. R. Harris, analyst.

10, 11. From Worthington quarry, near Trussville, Jefferson county. C. A. Meissner, analyst.

12-17. From Vanns, near Trussville. J. R. Harris, analyst.

18. Average of about 150 feet thickness of rock used for flux, Compton quarry, Blount county. J. L. Beeson, analyst.

19, 20. Stockhouse sample. Compton quarry. Wm. B. Phillips, analyst.

Table B.

Analyses of Trenton Limestones.

Number.	1	2	3	4	5	6	7	8	9	10
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	4.48	5.70	2.43	3.65	3.29	3.82	0.39	0.15	0.78	1.00
Iron and aluminum oxides	1.22	1.87	3.30	.91	1.49	1.96	.13	Tr	.35	.30
Calcium carb'te.	88.85	91.16	89.88	92.38	92.61	90.44	99.11	99.16	97.52	97.00
Magnesium carbt	3.52	......	......	......	......	......	.75	.75	1.27	Tr
Sulphur	......	......	......	......	......	......	......	......	......	Tr
Water, organic matter and loss	......	......	......	......	......	......	......	......	......	......

Number.	11	12	13	14	15	16	17	18	19	20
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	0.43	0.58	0.38	0.34	0.39	0.98	2.50	2.09	1.08	2.25
Iron and aluminum oxides	.42	.25	.47	.46	.37	.52	1.40	1.01	.63	.68
Calcium carb'te.	98.49	95.78	98.35	96.53	94.27	96.92	96.70	93.77	98.91	95.40
Magnesium carbt	.16	2.89	.30	2.17	4.47	1.08	......	2.48	.58	.94
Sulphur	......	......	......	......	......	......	......	......	......	......
Water, organic matter and loss	......	......	......	......	......	......	......	......	......	......

1. Average of several carloads flux rock from quarry at Vance, Tuscaloosa county, of Central Iron Company at Tuscaloosa. H. Buel, analyst.

2. Gate City quarry, Jefferson county. Average sample from the crusher. Henry McCalley, analyst.

3-6. Gate City quarry. J. W. Miller, analyst.

7, 8. Longview quarries, Shelby county. Used in lime burning. Report of Alabama State Geologist, 1875.

9. Jones quarry, near Longview. Report of Alabama State Geoligist, 1875

10. Rock Spring quarry, Etowah county. Used in lime burning and for flux. Wm. B. Phillips, analyst.

11-16. Rock from Calcis quarry, St. Clair county. J. R. Harris, analyst.

17-20. Shelby quarry, Shelby county. Used for flux in Shelby furnaces. Report of Alabama State Geologist, 1875.

Table C.

Analyses of Crystalline Marbles.

Number.	1	2	3	4	5	6	7
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	Tr	2.70	2.95	4.65	2.80	1.35	0.28
Iron and aluminum oxides.........	......	.40	1.15	.75	.48	.30	.28
Calcium carbnate	99.47	90.80	95.25	94.40	95.60	97.60	99.19
Magnesium carbonate	.38	Tr	.62	.41	.66	Tr	.14

1. Herd's upper quarry, Talladega county. Tuomey's Second Report.
2. Heard's quarry, sec. 16, T. 21, R. 4 E., Talladega county. Wm. B. Phillips, analyst.
3. Taylor's mill, Talladega county, white marble. Wm. C. Stubbs, analyst.
4. Taylor's mill, Talladega county, blue marble. Wm. C. Stubbs, analyst.
5. Taylor's mill, Talladega county. A. F. Brainerd, analyst.
6. Nix quarry, sec. 36, T. 20, R. 4 E., Talladega county, white marble. Wm. B. Phillips, analyst.
7. Gannt's quarry, sec. 2, T. 22, R. 3 E., Talladega county, white marble. A. F. Brainerd, analyst.

Table D.

Analyses of Clays—Paleozoic and Lower Cretaceous.

Number.	1	2	3	4	5	6	7	8	9
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	61.55	57.80	57.22	58.50	79.80	82.04	66.25	82.11	60.50
Alumina	20.25	25.00	24.72	18.28	11.75	12.17	22.90	11.41	26.55
Ferric oxide	7.23	4.00	7.14	10.22	1.75	Tr	1.60	1.40	.30
Lime	Tr	2.10	.49	1.19	.75	Tr	Tr	Tr	.90
Magnesia	.99	.80	1.88	1.40	Tr	.33	Tr	.66	.65
Alkalies	1.25	1.80	.40	.70	1.50	.60	.75	1.80	2.70
Ignition	6.19	7.50	7.09		4.11	4.33	9.05	4.00	7.90
	98.66	99.00	98.93	......	99.16	99.47	100.55	101.38	99.50

Number.	10	11	12	13	14	15	16	17	18
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	72.20	57.00	67.95	61.50	84.21	66.61	62.60	60.38	65.82
Alumina	22.04	17.80	20.15	26.20	9.75	21.04	26.98	20.21	24.58
Ferric oxide	.16	5.60	1.00	2.10	.69	2.88	.72	6.16	1.25
Lime	.50	2.10	1.00	.50	.70	.40	.40	.09	......
Magnesia	.40	1.20	Tr	.43	.14	.58	.36	.72	Tr
Alkalies	.60	6.00	1.87	.70	....	.70	.65	1.80	.60
Ignition	5.80	9.45	8.00	7.29	4.10	7.00	9.30	10.21	8.16
	101.70	99.15	99.97	98.72	99.59	99.21	101.01	99.57	100.41

Number.	19	20	21	22	23	24	25	26	27
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct
Silica	74.25	61.25	65.35	60.03	58.13	68.23	60.90	63.27	67.10
Alumia	17.25	25.60	21.30	24.66	24.68	20.35	18.98	19.68	19.37
Ferric oxide	1.19	2.10	2.72	3.69	3.85	3.20	7.68	3.52	2.88
Lime	.40	.25	.60	.13	.15	.34	Tr	1.30	Tr
Magnesia	Tr	.82	.86	.38	.32	Tr	Tr	Tr	.73
Alkalies	.52	1.35	Tr	Tr	1.78	.74	Tr	1.20	.67
Ignition	6.30	8.10	8.79	11.34	11.78	7.16	13.36	9.80	7.79
	99.39	99.47	99.62	100.23	100.51	100.02	100.92	98.77	98.54

Number.	28	29	30	31	32	33	34		
	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct	Pr ct		
Silica	65.58	68.10	65.49	70.00	67.50	66.45	64.90		
Alumina ...., ...	19.23	21.89	24.84	21.31	19.84	18.53	25.25		
Ferric oxide	4.48	2.01	Tr	2.88	6.15	2.40	Tr		
Lime	Tr	.80	1.26	.20	.12	1.50	Tr		
Magnesia	Tr	.28	Tr	Tr	.10	1.25	Tr		
Alkalies	....	.40	Tr	Tr	....	Tr	....		
Ignition	6.90	5.75	7.80	6.85	7.65	9.46	8.90		
	96.19	99.23	99.39	101.24	101.36	99.59	99.05		

Coal Measures..	1. Dark yellow shale from Coal Measures, W. H. Graves, near Birmingham, Jefferson county. 2. Light gray shale from same locality. 3. Shale from Coaldale, Jefferson county. Analysis by F. W. Miller. 4. Shale over coal seam, Cedar Grove Coal Mines, near Vance, Tuscaloosa county.
Lower Carboniferous	5-7 Fire clay, near Valley Head, DeKalb county. 8. China clay, Eureka mines, DeKalb county.

Silurian and Cambrian.	9.	China clay, Rock Run, Cherokee county (Dyke's ore bank.)
	10.	Fire clay, Rock Run, Cherokee county.
	11.	Pottery clay, Rock Run, Cherokee county.
	12.	China clay, J. R. Hughes, Gadsden, Etowah county.
	13.	Stoneware clay, Blount county.
	14.	Stevens, Fire clay, Oxanna, Calhoun county; probably too much free sand.
Lower Cretaceous (Tuscaloosa)	15.	Stoneware clay, Coosada, Elmore county.
	16.	Pottery clay, McLean's, near Edgewood, Elmore co.
	17.	Stoneware clay, Chalk Bluff, Elmore county.
	18.	Fire clay, Woodstock, Bibb county.
	19.	Fore clay, Bibbville, Bibb county.
	20.	Fire clay, Hulls Sta'n., A. G. So. R. R. Tuscaloosa co.
	21.	Pottery clay, H. H. Cribbs, A. G. So. R. R., Tuscaloosa county.
	22.	Pottery clay, J. C. Bean, M. & O. R. R., Tuscaloosa co.
	23.	Fire clay, J. C. Bean, M. & O. R. R., Tuscaloosa co.
	24.	Stoneware clay, Roberts' Mill, Pickens county.
	25.	Pottery clay, Cribbs' place, Lamar county.
	26.	Stoneware clay, H. Wiggins, Fayette county.
	27-28.	Pottery clay, W. Doty, Fayette county.
	29.	Blue clay, R. R. cut, near Glen Allen, Marion county.
	30.	China clay, Briggs Frederick, Marion county.
	31.	Pottery clay, 10 miles S. W. Hamilton, Marion co.
	32.	Pottery clay, Thos. Rollins, Franklin county.
	33.	Pottery clay, J. W. Williams, Pegram, Colbert co.
	34.	China clay, Pegram, Colbert county.

CHAPTER II.

THE PORTLAND CEMENT MATERIALS OF CENTRAL AND SOUTHERN ALABAMA.

The raw materials suitable for the manufacture of Portland cement, which occur in Central and Southern Alabama, are argillaceous limestones, purer limestones, and clays.

The limestones valuable as cement materials occur mainly at two horizons, viz., in the Selma chalk or Rotten limestone of the Cretaceous, and in the St. Stephens formation of the Tertiary. The clays available are residual clays from the decomposition of the two limestone formations above mentioned, the stratified clays of the Grand Gulf formation, and alluvial clays occurring in the river and creek bottoms. It is further possible that later investigation may show that some of the other stratified clays of the Tertiary formations are suitable, and this is especially likely to be the case with the clays of the lowermost Cretaceous or Tuscaloosa formation.

THE SELMA CHALK OR ROTTEN LIMESTONE.

Geological horizon.—The Cretaceous system in Alabama is susceptible of classification into four divisions, which are, in ascending order,

1, the Tuscaloosa, a formation of fresh-water origin, made up in the main of sands and clays in many alterations. In places the clays occur in deposits of sufficient size and of such a degree of purity as to make them of commercial value.

2, the Eutaw, which is of marine origin and composed of sands and clays more or less calcareous, but nowhere showing beds of limestone properly so called.

3, the Selma chalk, which is of marine origin, and is composed, in part at least, of the microscopic shells of Foraminifera. This formation, throughout the western part of the belt covered by it in Alabama, is about 1,000 feet in thickness, and is made up of beds of chalky and more or less argillaceous limestone. In a general way it

may be said that the lower and upper thirds of the formation contain 25 per cent. and upward of clayey matters mixed with the calcareous material, while the middle third will hold less than 25 per cent. of these clayey impurities.

4, the Ripley. This, like the preceding, is a marine formation, in which, generally, the calcareous constituents predominate, but in places it contains sandy and clayey beds.

From this summary it will be seen that the Selma chalk is the one of Cretaceous formations in Alabama which offers limestone in such quantity and of such composition as to be fit for Portland cement material.

General description.—As has been stated above, the Selma chalk is a calcareous formation throughout its entire thickness of about 1,000 feet. The rock, however, varies in composition between somewhat wide limits, and taking account of the composition we may readily distinguish three divisions of it. The rock of the upper or Portland division is highly argillaceous, holding from 25 per cent. and upward of clayey matters; portions of it are composed of calcareous clays or marls rather than limestone, and in these beds are found great numbers of fossils, mainly oysters. Along Tombigbee River these beds make the bluffs from Pace's Landing down nearly to Moscow, and on the Alabama they form the banks of the river from Elm Bluff down to Old Lexington Landing. The strata, as exhibited in these bluffs, consist of dark-colored, fossiliferous, calcareous clays, alternating with lighter-colored and somewhat more indurated ledges of purer, less argillaceous rock. At Elm Bluff, which is about 125 feet high, the upper half of the bluff is of this character. The lower half of the bluff is composed of rock more uniform in composition and freer from clay, and is the top of the middle part of the Selma formation (the Demopolis division), which is made up of limestone of more uniform character, containing, generally, less than 25 per cent. of clayey material.

In this middle or Demopolis division of the Selma formation the fossils are rarer than in either of the others, oysters and anomias being the most common forms. This variety of the rock forms the bluffs along Alabama River from Elm Bluff up to King's Landing. It is seen in its most typical exposure at White Bluff, where it is at least 200 feet in thickness, and

makes on the right bank of the river an almost perpendicular bluff. On Tombigbee River it extends from near Barton's Bluff past Demopolis up to Arcola and Hatch's Bluff. Its lowermost beds, a compact limestone of great purity, form the upper parts of Barton's and Hatch's Bluffs. On Little Tombigbee River the same rock makes the celebrated bluffs at Bluffport and at Jones Bluff (Epes), beyond which for several miles it is shown along the stream.

Judging from the width of its outcrop, this division of the Rotten limestone must be about 300 feet in thickness. It underlies the most fertile and typical "prairie" lands of the South. At intervals throughout this region the limestone rock appears at the surface in what are known as "bald prairies," so named from the circumstance that on these spots there is no tree growth. The disintegration and leaching out of the limestone leaves a residue of yellowish clay, which accumulates sometimes to a thickness of several feet in low places. This clay is used at the Demopolis plant in the manufacture of cement, and in most localities where suitable limestone is found the clay is present in sufficient quantity to supply the needs of the cement manufacturer.

At the base of this middle or Demopolis division occurs a bed consisting of several ledges of compact, hard, pure limestone, which weathers into curious shapes, and has received the names horse-bone rock and bored rock. This bed, as above mentioned, appears at the top of Hatch's Bluff; also at Arcola Bluff, and between Demopolis and Epes, at Jordan's Ferry, and other places. Where it outcrops across the country it makes a ridge easily followed and characterized by the presence on the surface of loose fragments of the limestone.

The lower part of the formation (the Selma division), like the upper, is composed of clayey limestone, in many places being rather a calcareous clay. The color is dark gray to bluish, and in most exposures there is a striping due to bands of light-colored, purer limestone alternating with the prevailing quality. Along Alabama River the strata of this division are seen in the bluffs from King's Landing up to Selma and beyond. On the Warrior River they are seen in the bluffs at Arcola, Hatch's, Millwood, and Erie, occupying in the last-named locality the upper part only of the bluff. On the Tombigbee, the bluffs at Gainesville, at Roe's, and Kirkpatrick's are formed mainly of

Plate 11.—Caves in Limestone, below Roe's Bluff, Tombigbee River.

the rocks of this division, while above Roe's, at Jordan's, occurs the line of junction of this with the middle division. Near this line of division there is a very characteristic feature to be observed at many points, viz., about 10 or 15 feet below the hard ledges of pure limestone forming the base of the middle (Demopolis) division the dark-colored argillaceous rock shows a tendency to flake off and weather into caves, sometimes to be seen for long distances along the bluffs, as on Alabama River just above King's Landing, on the Tombigbee below Roe's Bluff, and at Jordan's Ferry. This peculiarity is illustrated in Plate II. The outcrop of the argillaceous rocks of this division gives rise to black prairie soils, in which beds of fossil shells, mainly oysters, are common.

It has been suggested that the argillaceous rocks of this and the uppermost division could be mixed with the purer limestone of the middle division in such proportions as to constitute a good cement mixture. In this case it would be easy to select localities near the junction of the two divisions where both varieties of the rock could be quarried, if not in the same pits, at least in pits closely adjacent. This would do away with the need of adding other clay to the limestone. Localities of this sort would be found along the border north and south of the belt of outcrop of the white Demopolis rock.

Details of localities.—The general characters of the rock of this formation have been mentioned above, and it remains to give details of the special localities examined, together with analyses of the limestones collected. In making the collections material from the middle or Demopolis division of the formation has been generally chosen, since most of the limestone of the formation which contains 75 per cent. and upward of carbonate of lime is to be found in this division. At the same time specimens of the more argillaceous material, especially of the lower (Selma) division of the formation, have been taken for comparison and analysis, with a view to ascertaining whether or not it will be practicable to provide a cement mixture by using the proper proportions of the purer and more argillaceous materials.

Inasmuch as suitable material for cement manufacture can be had in practically unlimited quantity all along the outcrop of the pure limestone of the Demopolis division, the location of the plants for the manufacture of this product will be determined by

other considerations than the quality of the rock. Chief among these will be the facilities for transportation, cheapness of fuel, cost of labor and abundance of it at command.

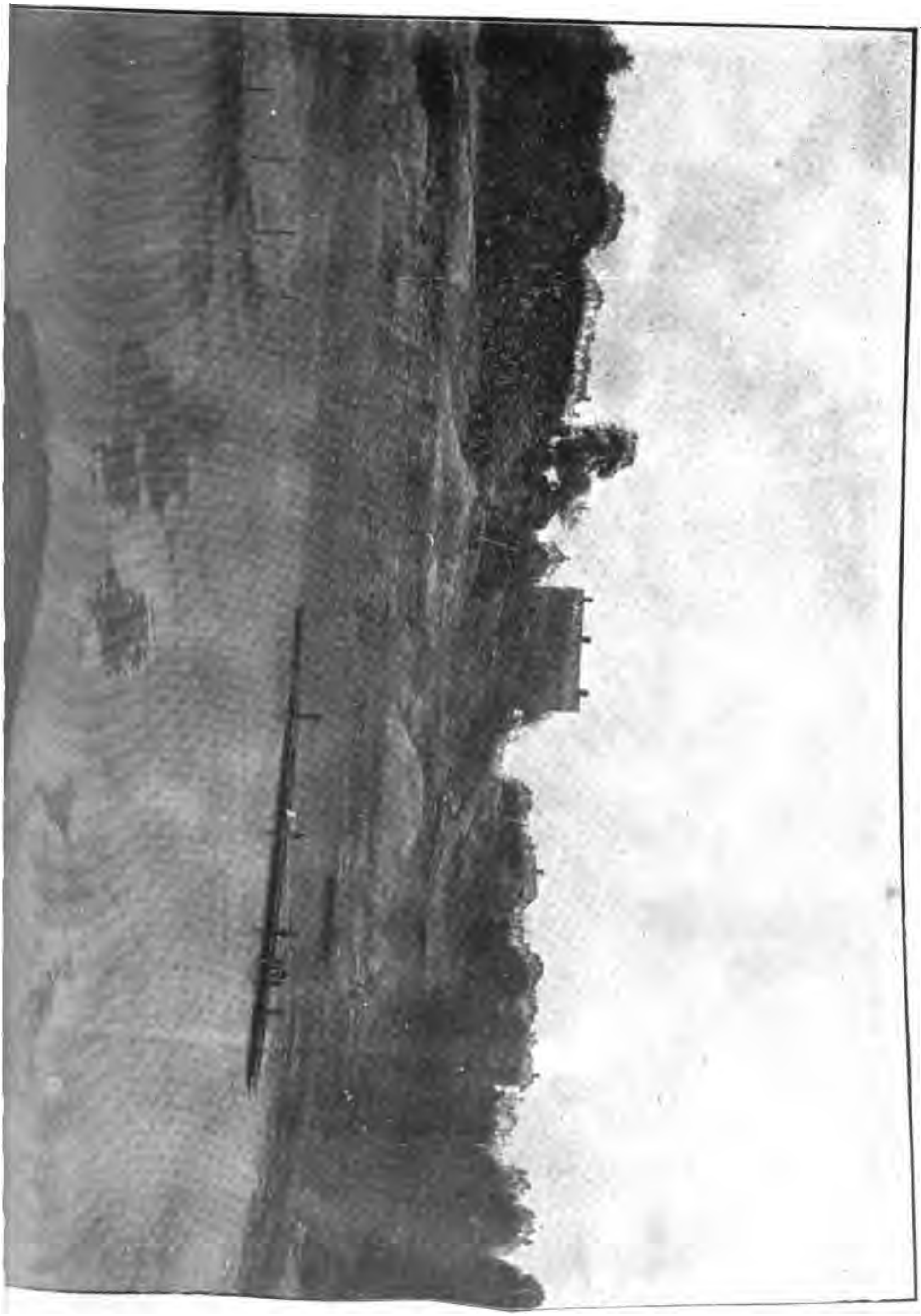
Examinations have consequently been confined to those localities which appear to be most favorably situated in these respects, and especially to those localities which are on navigable streams or on north-south railroad lines, or on both.

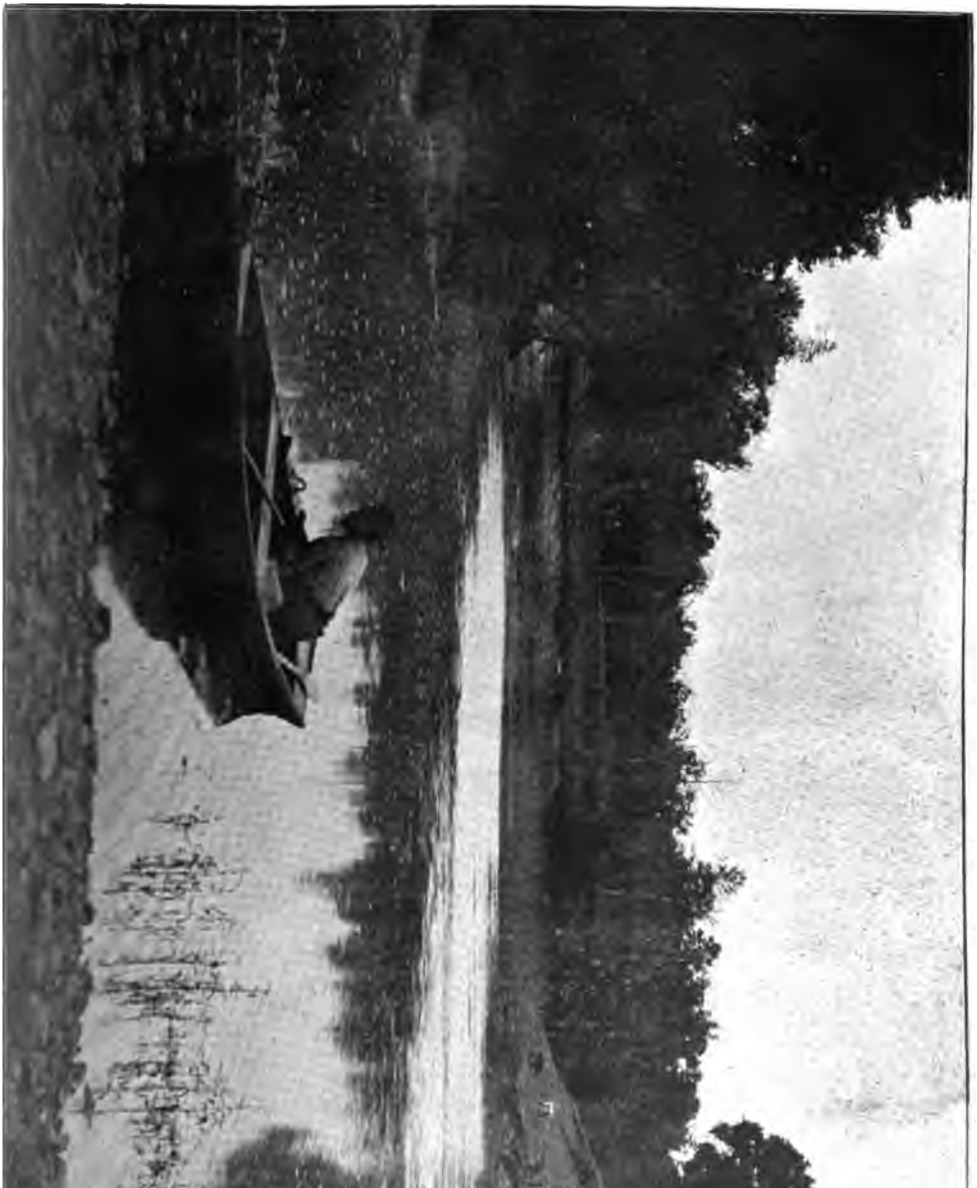
The first place considered on Tombigbee River is Gainesville, where the limestone appears on the river bluff in a thickness of 30 to 40 feet, beneath a heavy covering of Lafayette sands and pebbles. (Plate III.) A short distance inland from the river, however, the rock appears at the surface, and may be quarried without difficulty. Specimens have been taken from the different parts of the bluff near the ferry, which will show the composition of the limestone here (see analyses 1, 2, 3, and 4, Table E). Other specimens are from the Roberts place, 3 miles east of Gainesville—one of which was taken from the top of a 30-foot bluff; others from the surface 1 mile and 5 miles from the river (analyses 5 and 6.)

At Jones' Bluff, on the Tombigbee, near Epes station, on the Alabama Great Southern Railroad, the white limestone of remarkably uniform composition shows along the river bank for a distance of a mile or so, with an average height of perhaps 60 feet. (Plate IV.) Here the bare rock forms the surface, so that there would be no overburden to be removed in quarrying. The railroad crosses the river at this locality, which thus has the advantage of both rail and water transportation. From the lower end of this exposure down to Bluffport the white rock is seen at many points, e. g., below Lees Island, Hillman's (Plate V), Martin's Ferry, Braggs, etc. It generally has a capping of 15 to 20 feet of red loam and other loose materials.

Specimens have been analyzed from Epes and Hillmans (analyses 7, 8 and 9, Table E.)

At Bluffport (Plate VI) the white rock in places forms a bluff 100 feet or more in height along the right bank of the river for a distance of a mile or more. This is the counterpart of Jones' bluff, above mentioned, and the character of the material is shown by analysis No. 10. As at Epes, the rock extends up to the surface, so that the quarrying would be attended with little or no difficulty. Below the Bluffport bluffs the easterly course of the river brings it into the territory of the lower





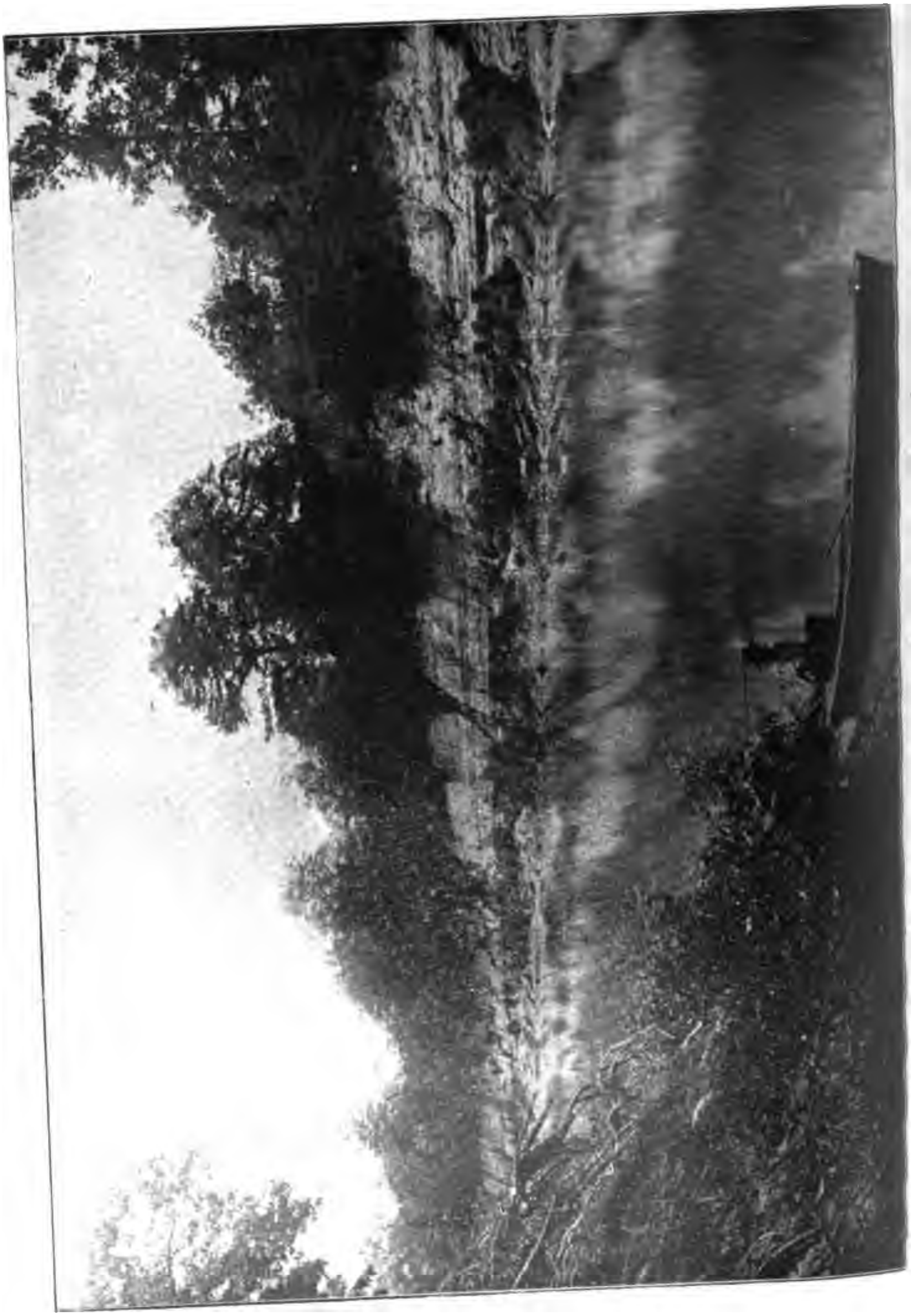


Plate VIII.—Roe's Bluff, Tombigbee River.

Plate XII.—Alaba[illegible]

ement Works, at Demopolis.

strata of the formation, and we do not see the white rock again below Jordan's Ferry, (Plate VII) except in thin patches at tops of some of the bluffs. The character of the material of these lower beds may be seen from the analyses of specimens taken from Jordans and Belmont and Roe's bluff, Nos. 11, 12, 13, and 14. The two specimens from the last-named locality represent the composition of the prevailing dark-colored argillaceous rock and of the lighter-colored ledges. (Plate VIII.)

At Demopolis there is an important occurrence of the white rock extending along the left bank from a mile above the landing to about 2 miles below, with an average height perhaps of 40 or 50 feet. (Plates IX and X.) The rock is remarkably uniform in appearance and probably in composition (analysis 17.) At McDowell's the main bluff is on the right bank and the rock is of great purity, as shown by analysis 16. The exposures continue down to Pace's Landing, 9 miles below Demopolis, and beyond this the bluffs are much darker in color and striped with lighter bands, characteristic of the strata of the upper part of the formation. Thence down nearly to Moscow occur the exposures of these upper beds.

Above Demopolis at Arcola and Hatch's bluff the bluish clayey limestones of the Selma division are seen in force, with the lowermost ledges of the Demopolis division—the horse-bone rock—capping them. Two analyses of these varieties at Hatches will show well the contrast in their chemical composition (analyses 19 and 20. (Plate XI.)

From Demopolis eastward the line of the Southern Railway is located on the outcrop of this white rock, at least as far as Massillon, where it passes into the territory of the lower Selma division. Two miles from Demopolis on this road is the cement manufacturing plant of the Alabama Portland Cement Company, with six kilns in place. The quarry is on the opposite side of the railroad track from the kilns, but only a few hundred feet distant. (This plant with quarry in the foreground is shown in Plate XII.) The clay used is the residual clay from the decomposition of the limestone, and is obtained from the river bank a few yards away. The composition of the rock and of the clay used in the manufacture is shown by analyses 15, 18, and 31, Table E, and 1, Table G. A specimen taken from Knox wood station, between the cement works and Demopolis station, shows similar composition. The analyses below given (10, 11,

12 of Table G) show the chemical character of the cement manufactured at Demopolis.

At Van Dorn station the white rock outcrops in the fields over considerable territory, (Plate XIII), and just east of the station there is a deep cut through it. Analyses from about Van Dorn show sufficiently well the character of the material at these points (analyses 21 and 22 of Table E.)

About Uniontown the bare rock is exposed at numerous points, and the advantages of this place for the location of manufacturing plants seem to be very great. Specimens have been taken from the Bradfield and Shields places, west of the town, and from the Pitts place east, and from a point south of the town along the McKinley road. Other specimens have come from plantations near the road for several miles eastward and the analyses are appended (analyses 23, 24, 25, 26, 27 and ~

The composition of the residual clay overlying the limestone at the Pitts place is shown in analysis No. 2 of Table G, and that of a similar clay from the "Graveyard Hill" on the Morgan place, by analysis No. 3 of same table.

South of Massillon, near the crossing of the Southern and Louisville and Nashville railroads, in the vicinity of Martin's station, the white rock shows in numerous exposures through the fields, making a country somewhat similar to that about Uniontown. At many points the rock has no overburden, and is admirably adapted to cheap quarrying. On the banks of Bogue Chitto Creek, near Martin's station, on the Milhous place, the rock is exposed in a bluff with a bed of plastic clay overlying, but here it is below a considerable thickness of red loam and sands of the Lafayette formation. The character of the rock at Milhous station, west of Martin's, may be seen from the analysis No. 29, Table E.

The same rocks make the great bluff of White Bluff, on Alabama River, (Plate XIV.) Specimens were selected from this bluff at two points—one about halfway down the bluff, the other twenty feet lower. Generally there is a capping of the red loam and sands of the Lafayette over the limestone, but near the upper end of the bluff the white rock extends to the summit, where it has a capping of plastic clay only. The charaster of the limestone from this locality is shown in analysis 30, Table E, and that of the overlying residual clay in analysis 4 of Table G.

At Elm Bluff, as has already been shown, the upper and middle divisions of the formation are in contact. (Plate XV.)

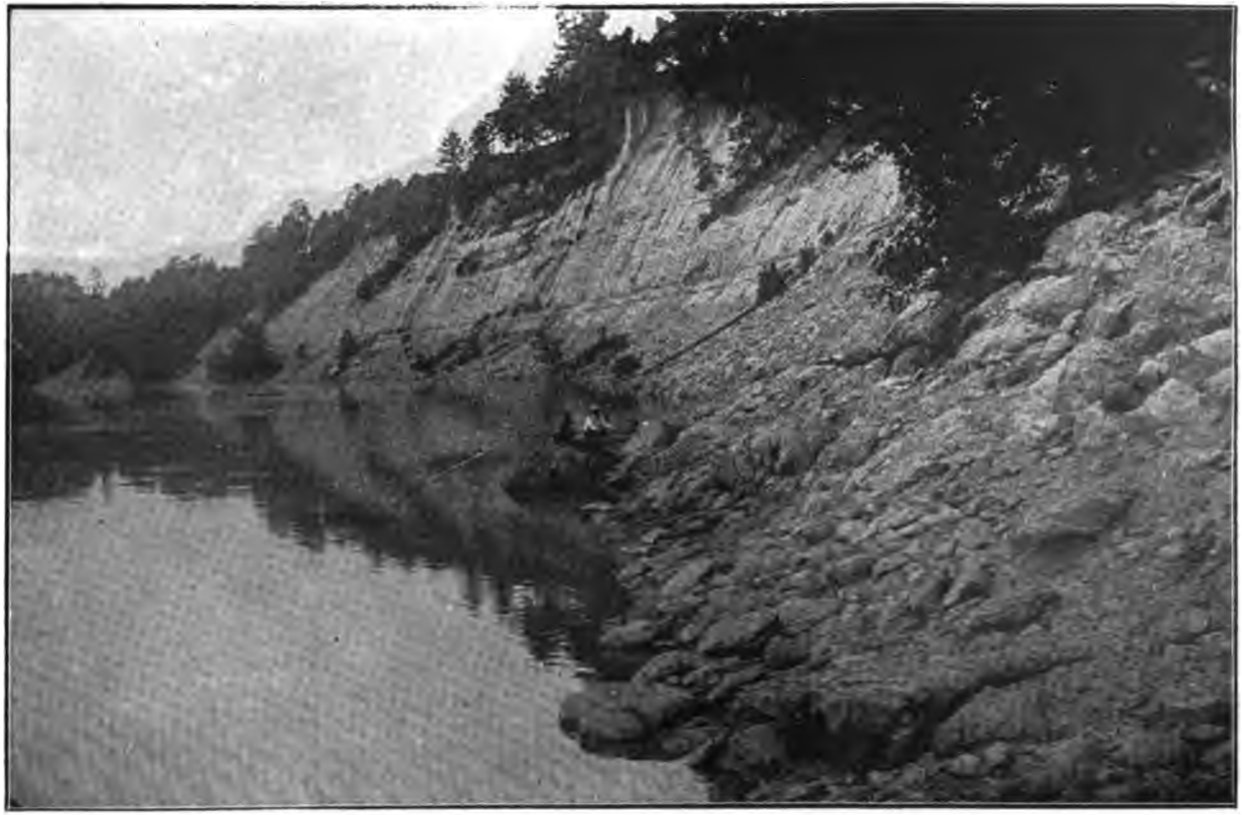


Plate XIV.—White Bluff, Alabama River.

Plate XV.—Elm Bluff, Alabama River.

At King's Bluff the middle and lower parts of the formation are in contact. At the other bluffs of the river between King's Landing and Selma the rock of the lower division is exhibited. No. 32 (Table E) is of the rock at the steamboat landing in Selma; No. 33 of rock occurring near Selma; No. 34 from Cahaba; and No. 35 from Benton.

These analyses show that the rock of this division is in general too clayey for the best cement rock, but it might be mixed with the purer limestone of Uniontown, or Demopolis in making up a cement mixture.

To summarize: From Demopolis eastward along the line of the Southern Railway, by Van Dorn, Gallion, Uniontown, Massillon, and thence by Martins and Milhous stations to White Bluff, the white or Demopolis type of rock appears at the surface in clean exposures at almost innumerable points, either immediately on the railroad or at very short distance from it. So far as the quality, quantity, and accessibility of the limestone rock are concerned, manufactories of cement might be located almost anywhere in this territory. From Demopolis westward the same conditions prevail up the river to Epes, and thence to Gainesville, beyond which point the white rock is to the west of the river at greater or less distance.

East of Alabama River the outcrop of the cement rock is crossed by the Louisville and Nashville Railroad (Repton branch), as before stated, between Berlin and Pleasant Hill stations. At Benton, on Alabama River, and on the railroad, the limestone has the composition shown by analysis 35.

On the Montgomery and Selma road, at the crossing of Pintlala Creek near Manack station, the limestone is exposed in the creek banks and in the open fields, often with little or no overburden. In Table E are given analyses of a specimen from the fields along the wagon road (No. 36), and from the creek bank (No. 37.)

On the main branch of the Louisville and Nashville Railroad the white rock shows between the city and McGhees switch, and an analysis of a specimen from McGhees is given (No. 38.) Somewhat similar, but rather better, is the limestone from H. A. Jones, 8 miles south of Montgomery, shown in analysis No. 39.

Examinations have not been carried beyond Montgomery, but it is known that the white prairie rock is crossed by the Central of Georgia Railroad between Matthews and Fitzpatrick stations, and there seems to be no doubt that along this stretch of the road suitable rock will be found convenient to the line.

Table E.

Analyses of Crateceous Limestones.

Locality.	Silica.	Iron and aluminum oxides.	Calcium carbonate.	Magnesium carbonate.	Sulphuric anhydride.	Total sulphur.	Water and organic matter.
1 Gainesville Bluff, Tombigbee river, 5 feet from top of bluff; R. S. Hodges, analyst	18.46	16.04	56.71	1.69	1.32	.....	5.78
2 Gainesville Bluff, Tombigbee river, lower part of bluff; R. H. Hodges, analyst	14.50	11.64	67.67	2.26	1.97	.....	1.96
3 Gainesville limestone; F. P. Dewey, analyst	18.42	10.79	65.21	1.57	.30	0.83	.....
4 Gainesville limestone; A. W. Dow, analyst	27.25	15.96	54:00	1.11	.44	1.23	.....
5 Robert's place, near Gainesville, top of bluff; R. S. Hodges	12.10	10.70	75.57	1.24	.69	.....	1.70
6 Robert's place near Gainesville, 5 feet above water; R. S. Hodges	14.28	11.80	69.75	1.50	1.02	.....	1.65
7 Jones Bluff, at Epes; R. S. Hodges	4.78	6.42	86.28	1.02	......	.....	1.30
8 Jones Bluff, at Epes; Dr. Mallett	3.23	3.96	80.48	.53	......	.....	2.22
9 Hillmans Bluff, below Epes; R. S. Hodges	10.08	9.47	77.43	1.30	......	.....	1.99
10 Bluffport ferry, Tombigbee river; R. S. Hodges	8.10	5.40	85.10	1.25	......	.....	.....
11 Jordans ferry, Tombigbee river; R. S. Hodges	......	......	67.28	1.87	......	.....	1.53
12 Belmont Bluff, Tombigbee river; R. S. Hodges	21.00	15.60	55.84	2.12	......	.....	5.44
13 Roes Bluff, Tombigbee river, main part of bluff; R. S. Hodges	20.40	15.76	55.82	2.10	......	.....	5.92
14 Roes Bluff, Tombigbee river, light-colored ledges; R. S. Hodges	9.68	8.70	78.52	1.02	......	.....	2.08
15 Demopolis limestone, F. P. Dewey; U. S. Mint, analyst	13.32	7.74	73.94	1.40	.27	.64	.....
16 McDowells Bluff, below Demopolis; R. S. Hodges	3.82	3.86	90.40	1.15	......	.....	.77
17 Demopolis limestone; Dr. J. W. Mallett, analyst	12.13	7.45	77.69	.72	......	.....	2.49
18 Material used in Demopolis' Cemen Wks; R. S. Hodges, analyst.	7.61	7.62	80.71	1.05	1.62	.....	1.36
19 Hatch's Bluff, Warrior river above Demopolis; main part of bluff; R. S. Hodges	25.90	19.44	44.78	2.68	......	.....	7.20
20 Hatch's Bluff, Warrior river above Demopolis; ledges at top of bluff; R. S. Hodges	1.78	2.34	93.52	1.38	......	.....	.98

Analyses of Crateceous Limestones.—Continued.

Locality.	Silica.	Iron and aluminum oxides.	Calcium carbonate.	Magnesium carbonate.	Sulphuric anhydride.	Total sulphur.	Water and organic matter.
21 At VanDorn station, from roadside; R. S. Hodges	8.90	8.26	80.47	1.30	......	.....	1.07
22 At VanDorn station, railroad cut east of station; R. S. Hodges	9.80	7.85	78.77	1.04	......	.....	2.54
23 Uniontown, P. H. Pitt's Home place; R. S. Hodges	10.86	8.40	75.35	1.35	......	.....	4.04
24 Uniontown, P. H. Pitts, Houston place; R. S. Hodges	13.58	9.20	72.21	1.98	......	.....	3.03
25 Uniontown, P. H. Pitts, Rural Hill place; R. S. Hodges	12.10	9.80	74.52	1.17	......	.....	2.41
26 Uniontown, 1 mile south on McKinley road; R. S. Hodges	7.56	7.18	83.45	1.53	......	.....	.....
27 Uniontown, Bradfield place; R. S. Hodges	17.77	9.24	65.96	1.52	......	.....	5.51
28 Uniontown, Shields place; R. S. Hodges	19.62	11.71	62.81	2.04	......	.....	2.49
29 R. R. cut, Milhous station, So. Ry. Dallas county; R. S. Hodges	10.50	7.24	80.10	.98	......	.....	1.18
30 White Bluff, Alabama river, lower part of bluff; R. S. Hodges	17.44	11.48	64.35	1.61	......	.....	5.22
31 Limestone used in cement works, Demopolis; analysis furnished by T. G. Cairns	9.88	6.20	77.12	1.08	......	.....	5.72
32 Limestone from bluff at steamboat landing, Selma; F. W. Miller, analyst	16.11	11.22	65.08	2.42	1.40	.....	3.37
33 Near Selma, white rock; O. M. Cawthon, R. S. Hodges	18.66	13.42	64.10	2.58	.08	.....	1.16
34 Limestone from Cahaba, Alabama river; Dr. Mallet	19.64	9.40	65.81	.79	......	.....	3.58
35 Limestone from Benton, Alabama river; Dr. W. B. Phillips	19.74	11.67	54.83	5.14	.85	.....	4.96
36 Limestone from Manack station, Lowndes county; R. S. Hodges	13.50	11.46	67.16	1.08	1.01	.....	5.79
37 Limestone, Manack station; Dr. B. B. Ross, analyst	13.20	9.00	74.26	1.46	......	.....	.....
38 Limestone, McGhee's Switch, Montgomery co.; R. S. Hodges	21.98	14.78	54.67	1.39	.11	.....	7.07
39 Limestone, H. A. Jones, 8 miles S. of Montgomery; R. S. Hodges	14.90	14.34	63.28	1.47	......	.....	6.01

THE ST. STEPHENS LIMESTONE.

General Description.—The St. Stephens or White limestone formation of the Alabama Tertiary, which includes the uppermost of the Eocene strata, is in general equivalent to the Vicksburg limestone of the Mississippi geologists.

In Alabama it exhibits three rather well-defined phases, which in descending order are (1) the Upper or Salt Mountain division, observed at one locality only in Clarke county; (2) the Middle or St. Stephens division, and (3) the Lower or Jackson division. Of these it is only the middle division with which we are here concerned, since the first is, so far as known, restricted to one locality, and the third is seldom exposed along Alabama rivers and railroads.

The following section of the St. Stephens Bluff, Tombigbee River, (Plate VI), will give an idea of the strata of this division:

Section of St. Stephens Bluff.

	Feet.
1. Red residual clay	1 to 5
2. Highly fossiliferous limestone holding mainly oysters, and full of holes, due to unequal weathering	10 to 12
3. Orbitoidal limestone (chimney rock), a soft, nearly uniform porous limestone, making smooth perpendicular face of the bluff except where bands of harder limestone of very nearly similar composition alternate with the softer rock. Both varieties hold great numbers of the circular shells of *Orbitoides mantelli*. These harder ledges are nearly pure carbonate of lime, take a good polish, and are often burned for lime..............	60
4. Immediately below 3, for 5 or 6 feet, the strata were not visible, being hidden by the rock falling from above, but the space seems to be occupied by a bluish clay. Then follows a soft rock somewhat of same consistency as No. 3 above, but containing a good deal of green sand. The fossils are mostly oysters and *Plagiostoma dumosa*. This bed is in places rather indurated superficially, and forms projecting ledges................	10 to 15

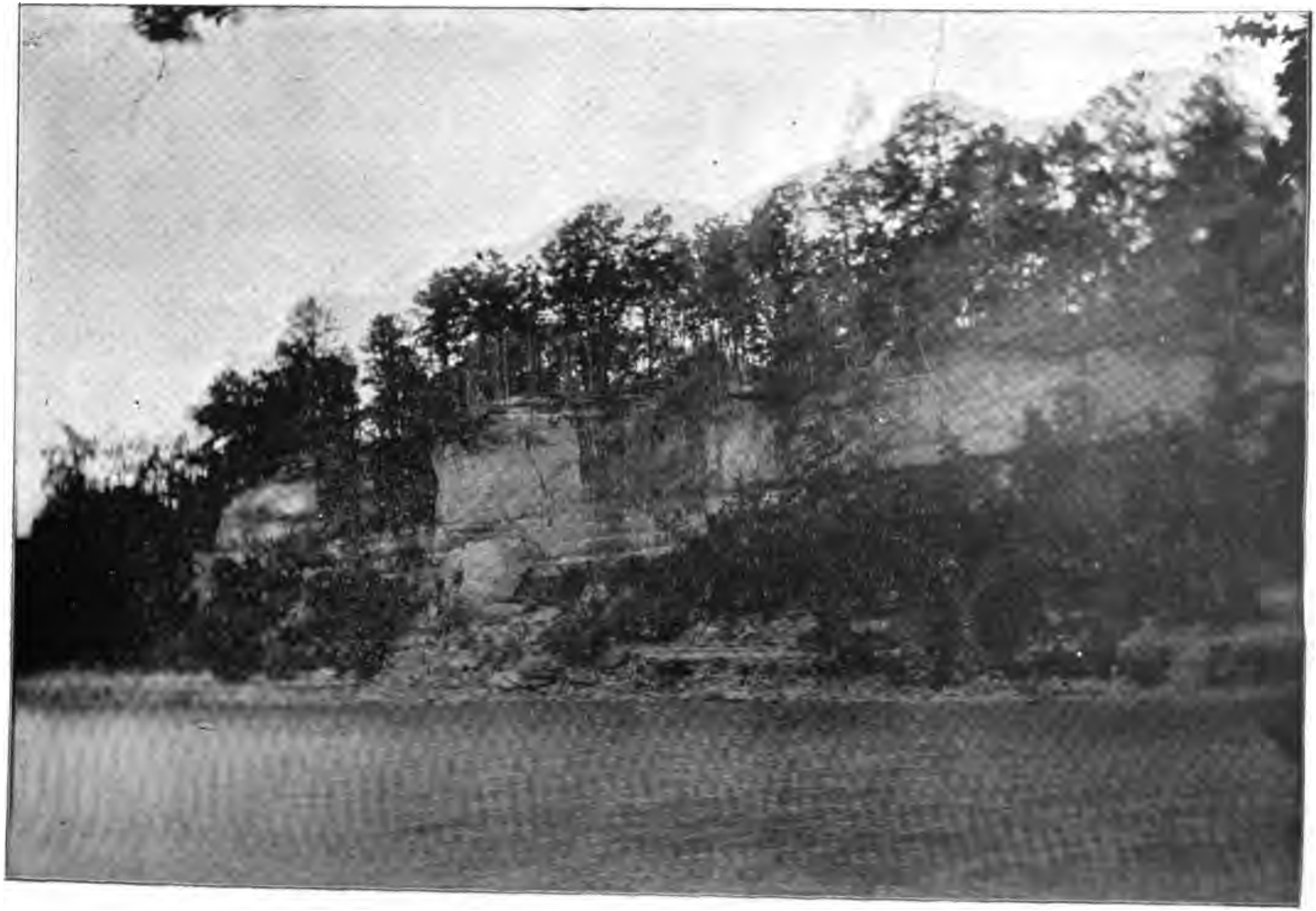


Plate XVI.—St. Stephens Bluff, Tombigbee River.

5. Bluish clayey marl with much green sand, containing the same fossils as No. 4. It washes or caves out from under No. 4, which overhangs it....................	4 to 5
6. Massive joint clay, yellow on exposed surface, blue when freshly broken; no fossils observed. Extends below the water level to unknown depth; exposed	3 to 4

The rock of this formation, which seems to be the best suited for cement material, is the soft "chimney rock" or orbitoidal limestone of bed No. 3 above. This usually quarried for chimneys and other constructions by sawing it out and dressing it down with a plane into blocks of suitable size, which are then laid like brick.

The numerous analyses given below will show that this rock is a purer limestone than most of the material of the Selma chalk of the Cretaceous formation above considered. In cement making it will, in consequence, require a larger proportion of clay to be mixed with it, and the question of obtaining suitable clay in sufficient quantity and in close proximity becomes one of some importance. The residual clay left after decomposition and leaching of the limestone seems to be fairly well adapted to the purpose. Besides this residual clay some analyses have been made of the clays of the river and creek bottoms of the country near the limestone outcrops, and of the clays of the Grand Gulf formation, which very generally in this section overlies the limestone. Some analyses of the last named clays have been made from material occurring near St. Stephens, and near Manistee Junction on the Repton Branch of the Louisville and Nashville Railroad. At this last-named locality the clay is present in sufficient quantity to be of value if the composition is suitable.

Details of Localities.

St. Stephens.—The first locality to be considered is the bluff at St. Stephens, a section of which has been given, and it may be taken as a typical section of the formation everywhere. At St. Stephens the whole of the soft orbitiordal limestone or "chimney rock" might be used, as the composition is uniform throughout. The overlying harder limestone has almost the same composition, but it is less easily crushed and handled. It may be quarried here from the surface down, as it is covered only by a thin layer of residual clay. The characters of the limestone and of the clay from here are sufficiently well shown

by the subjoined analyses (No. 1 of Table F, and 5 and 6, Table G.) The character of the clay of Grand Gulf formation near St. Stephens is shown in analysis No. 8 of Table G.

Below St. Stephens there is deep water to Mobile, with the exception of one bar, which may be removed without much trouble or expense.

Oven Bluff.—From Hobson's quarry, just above the Lower Salt Works Landing, down to Oven Bluff, a distance of 2 miles, the orbitoidal limestone or chimney rock occurs at the base of bluffs of Tertiary age.

At the quarry the hard limestone, which is being taken up for riprap work, lies ,as at St. Stephens, just above the soft chimney rock. Along the stretch of river above described this chimney rock is seen in a bed 15 to 20 feet in thickness, just above the river bottom, and is easily accessible. Analysis 2, Table F, of a sample from Oven Bluff will show the quality of the limestone here. As regards clay three varieties have been examined, a residual clay from over the limestone, a swamp-bottom clay from the low grounds of Leatherwood Leatherwood Creek, and clay from strata of the Grand Gulf formation which here overlies the St. Stephens limestone. The analyses of these clays have not yet been made.

The first shoal in the river above Mobile is a few miles above Oven Bluff, so that from this place down there is a 9-foot channel at all seasons, which will give to Oven Bluff a certain advantage over other localities in regard to transportation. The shoal mentioned is one which can be removed, so that St. Stephens may be classed with Oven Bluff as regards transportation by water, except that the former is some miles farther from the Gulf than the latter.

Analyses by Dr. Mallett of other specimens of this chimney rock are here presented. No. 8, Table F, is of a specimen from Colonel Darrington's place, in the lower part of Clarke county near Gainestown, and 9 and 10 are from other localities in Clarke county near the rivers.

Localities along the line of the Southern Railway.—At Glendon station, a few miles east of Jackson, there is an exposure of the chimney rock close to the track. The rock here is about 20 feet thick, and the limestone is covered by a bed of red residual clay similar to that at St. Stephens and Oven Bluff. The same chimney rock may be seen along the road between the sta-

tion and Jackson, and no doubt it occurs from Glendon up to Suggsville station, within convenient reach of the railroad. At Suggsville station the same rock occurs along the road leading from station to the town. This place is within a short distance of the railroad.

Between Suggsville and Gosport, the country rock is the St. Stephens limestone, but no particular attention was given to it for the reason that no railroad crosses the county along this line.

Along Alabama River.—At Perdue Hill the St. Stephens rock outcrops near the base of the hills which descend to the terrace on which the town of Claiborne stands. The bluff at Caliborne Landing shows near the summit the calcareous clay or clayey limestone which lies at the base of the St. Stephens formation, and which is generally thought to be the equivalent of the Jackson group of the Mississippi geologists. It is quite possible that this rock, where it occurs in sufficient quantity, may be suitable for cement making,, since it has a composition not far different from much of the Rotten limestone or Selma chalk. No investigations have yet been made concerning it, for the reason that there are comparatively few points where it appears in adequate thickness and in favorable localities as regards transportation.

At Marshall's Landing, just above the mouth of Randon's Creek, is the first exposure of the chimney rock along Alabama River. This occurs at the top of the bluff. It has the usual covering of residual clay, and the analyses presented (3 of Table F, and 7 of Table G,) will show the composition of the two. Below the orbitcidal or chimney rock at Marshall's there are 20 feet or more of a porous limestone, the analysis of which is given in Table F, No. 4. In the same bluff there are beds of calcareous clay which might possibly be used in mixing with the limestone. At the landing these would be difficult to quarry because of overlying strata, but they would certainly be found without cover along the bluffs above Marshall's if they should prove of value.

From Marshall's down to Gainestown Landing the river bluffs show beds of the limestone at numerous points. At Gainestown, the topmost bed of the St. Stephens, the hard crystalline limestone occurs not far above the water level in the river. This stone has been cut and polished and proves to be

a first-rate marble, inasmuch as it takes a good polish and shows agreeable variations in color. The soft chimney rock underlies the hard limestone here as at other points.

At Choctaw Bluff, some miles below Gainestown, there is the last exposure of the Tertiary limestones on the river. The material is an argillaceous limestone with numerous fossils, but it seems hardly likely to be of use in cement making.

Between Alabama River and the main line of the Louisville and Nashville Railroad.—A few miles east of Marshall's Landing, at Manistee Mills, the terminus of a sawmill road, there is a quarry of the chimney rock, conveniently situated as to transportation, since it is on the railroad. Across the country to the Repton Branch of the Louisville and Nashville Railroad, the St. Stephens limestone may, of course, be found at thousands of places, but no mention is made of these occurrences where they do not lie on railroad line.

Below Monroe Station, near Drewry on the Repton Branch, this road crosses the line of outcrop of the chimney rock, which at a number of points in the vicinity of Drewry lies within easy reach of transportation.

A few miles below Drewry, at Manistee Junction, there is a fine exposure of Grand Gulf clays in railroad cuts, both north and south of the station.

Analysis is given (No. 9 of Table G), of the clays from these cuts, from which their suitability from admixture with the limestone may be determined.

On the main line of the Louisville and Nashville Railroad.—The chimney rock may be found at many points below Evergreen in the vicinity of Sparta and Castleberry stations. There are many bluffs of this rock on the banks of Murder Creek in this vicinity, and there are several quarries from which the stone has been obtained for building purposes, within short distance of the railroad line. At the foot of Taliaferro's Heights the limestone forms high bluffs on the creek; at Ellis Williams Spring there are bluffs with the soft rock at the base and the hard horse-bone rock at the top, and on the creek bank, a few hundred yards away, is one of the quarries mentioned above. In fact the localities where the rock may be found within convenient distance of the railroad, and in a position favorable to

cheap quarrying, are numerous in all this region. No clays were seen except the usual residual clays from the decomposition of the limestone and a clay occurring close to Evergreen in the pits of Wild Brothers. Analyses 5, 6 and 7 of Table F, will show sufficiently well the character of the limestone in this section.

The Evergreen occurrences have attracted attention because of their location on the line of a great railroad system within short distance of tide water.

Farther to the east this limestone formation extends across Alabama and into Georgia and Florida, but as there is no north-south railroad east of the Louisville and Nashville at this time, the investigations have gone no further.

To summarize: While the St. Stephens limestone outcrops across the State from the Mississippi line to the Chattahoochee River, often occupying broad belts, attention has been concentrated on those localities which lie upon navigable streams or upon railroad lines terminating in Gulf ports. As compared with the Demopolis division of the Selma chalk, this limestone is more uniform in composition, higher in lime content, softer and more easily quarried and crushed, and in geographical position many miles nearer the Gulf.

Its thickness, on the other hand, is much less, although sufficient to supply an indefinite number of manufactories with raw material for cement.

Table F.

Analyses of Tertiary Limestones.

Locality.	Silica.	Iron and aluminum oxides.	Calcium carbonate.	Magnesium carbonate.	Sulphuric anhydride.	Water and organic matter.
1 St. Stephens orbitoidal limestone, St. Stephens, Tombigbee river; R. S. Hodges, analyst	2.28	2.04	92.85	1.92	.13	....
2 Orbitoidal limestone, "Chimney Rock," Oven Bluff, Tombigbee river; R. S. Hodges	4.18	3.26	89.32	2.38	.15	.81
3 Orbitoidal limestone, Marshall's Landing, Alabama river, Monroe county; R. S. Hodges	2.52	1.50	94.07	1.90	.08	....
4 Limestone underlying the orbitoidal rock, Marshall's Landing; R. S. Hodges	11.44	3.34	80.46	3.09	.15	1.52
5 Chimney Rock, Taliaferro's Heights, near Evergreen, Conecuh county; R. S. Hodges	2.84	2.16	91.31	1.83	.07	1.79
6 St. Stephens orbitoidal limestone, near Evergreen; Dr. W. B. Phillips, analyst	1.26	1.72	96.09	.65	.02	.65
7 Orbitoidal limestone near Evergreen; D. W. B. Phillips	2.75	2.73	93.31	.23	.02	.60
8 St. Stephens orbitoidal limestone, Col. Darrington's, near Oven Bluff, Clarke co; Dr. J. W. Mallet	1.69	2.12	94.84	.96	......	....
9 St. Stephens orbitoidal limestone, Clarke co. near river; Dr. J. W. Mallet, analyst	2.44	.27	94.85	......	......	....
10 St. Stephens orbitoidal limestone, Clarke county near river; Dr. J. W. Mallet, analyst	4.15	1.29	93.19	1.09	......	....

Table G.

Analyses of Clays (Cretaceous and Teritary) and Cement.

Number of anaylsis.	Silica.	Iron and aluminum oxides.	Calcium oxide.	Magnesium oxide.	Sulphuric anhydride.	Total sulphur.	Ignition.
1 Residual clay over limestone, at Demopolis Cement Works; R. S. Hodges, analyst	55.64	26.25	.91	1.97	Tr	....	13.90
2 Residual clay over limestone at P. H. Pitts' Home Place, Uniontown; R. S. Hodges	69.57	19.04	37	......	.....	....	9.68
3 Residual clay, Graveyard Hill, Morgan Place, Uniontown; R. S. Hodges	56.74	28.10	.70	1.27	Tr	....	13.80
4 Residual clay, Reid Place, White Bluff, Alabama river, Dallas co.; R. S. Hodges	56.90	27.71	.86	1.64	.09	....	11.26
5 Residual clay over orbitoidal limestone, St. Stephens, Washington county; R. S. Hodges..............	59.71	24.79	.37	......	.....	....	14.96
6 Residual clay over limestone, St. Stephens Bluff; R. S. Hodges.....	44.94	36.36	5.14	1.20	.....	....	13.77
7 Residual clay over limestone at Marshall's Landing, Alabama river, Monroe county; F. W. Miller, analyst	51.30	33.22	1.37	.96	.41	....	9.42
8 Grand Gulf clay, west of St. Stephens, Washington co.; R. S. Hodges	60.68	25.60	.48	.38	Tr	....	9.92
9 Grand Gulf clay, Manistee Junc., Monroe county; F. W. Miller, analyst	66.60	25.86	.34	.34	.89	....	5.11
10 Cement manufactured by Alabama Portland Cement Co., Demoppolis; A. W. Dow, U. S. inspector of asphalts and cements, analyst.	20.25	13.44	63.60	1.03	.41	0.99	.....
11 Cement manufactured by Alabama Portland Cement Co., Demopolis; analysis from T. G. Cairns, general manager	19.99	13.74	61.36	.61	.....	....	.....
12 Cement manufactured by Alabama Portland Cement Co., Demopolis; R. S. Hodges, analyst......	19.99	13.63	63.82	.83	1.16	....	.....

GEOLOGICAL SURVEY OF ALABAMA

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The Mineral Resources of Alabama

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Bulletin 9

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, State Geologist.

INDEX TO

The Mineral Resources

OF ALABAMA.

BY

EUGENE A. SMITH

AND

HENRY McCALLEY.

With Map and Illustrations.

Brown Printing Company,
Montgomery, Ala.,
1904.

To His Excellency, Gov. William D. Jelks:

Sir: I have the honor to submit herewith an Index to the Mineral Resources of Alabama.

As the name implies, this document is intended rather to direct the attention of those interested to the various natural resources of the State which are considered capable of being profitably utilized, and to the sources from which more detailed information may be derived, than to be a complete or adequate presentation of the subject.

Very respectfully,

EUGENE A. SMITH,
State Geologist.

University of Alabama,
April 30, 1904.

CHAPTER III.

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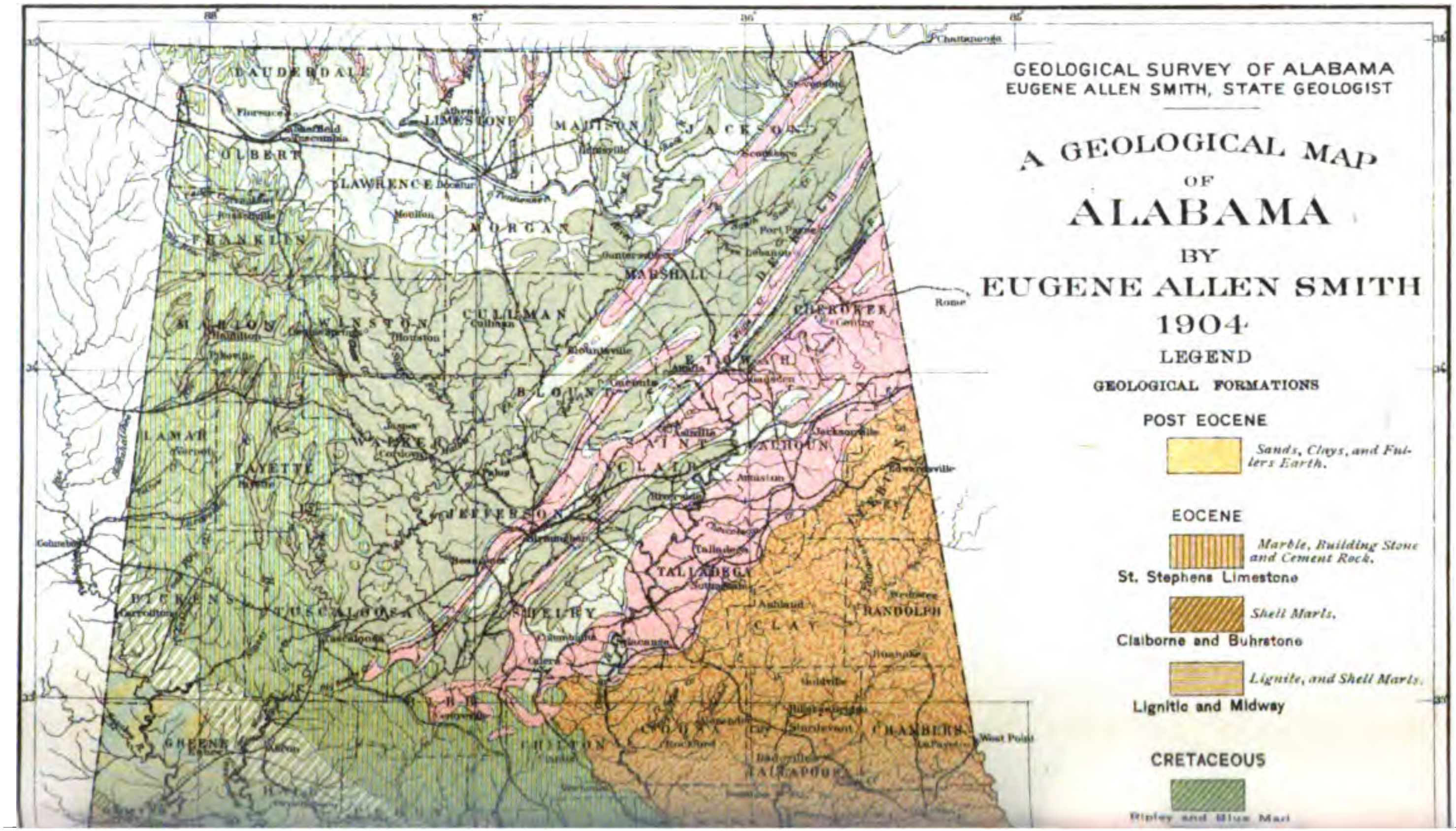
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BY
EUGENE ALLEN SMITH
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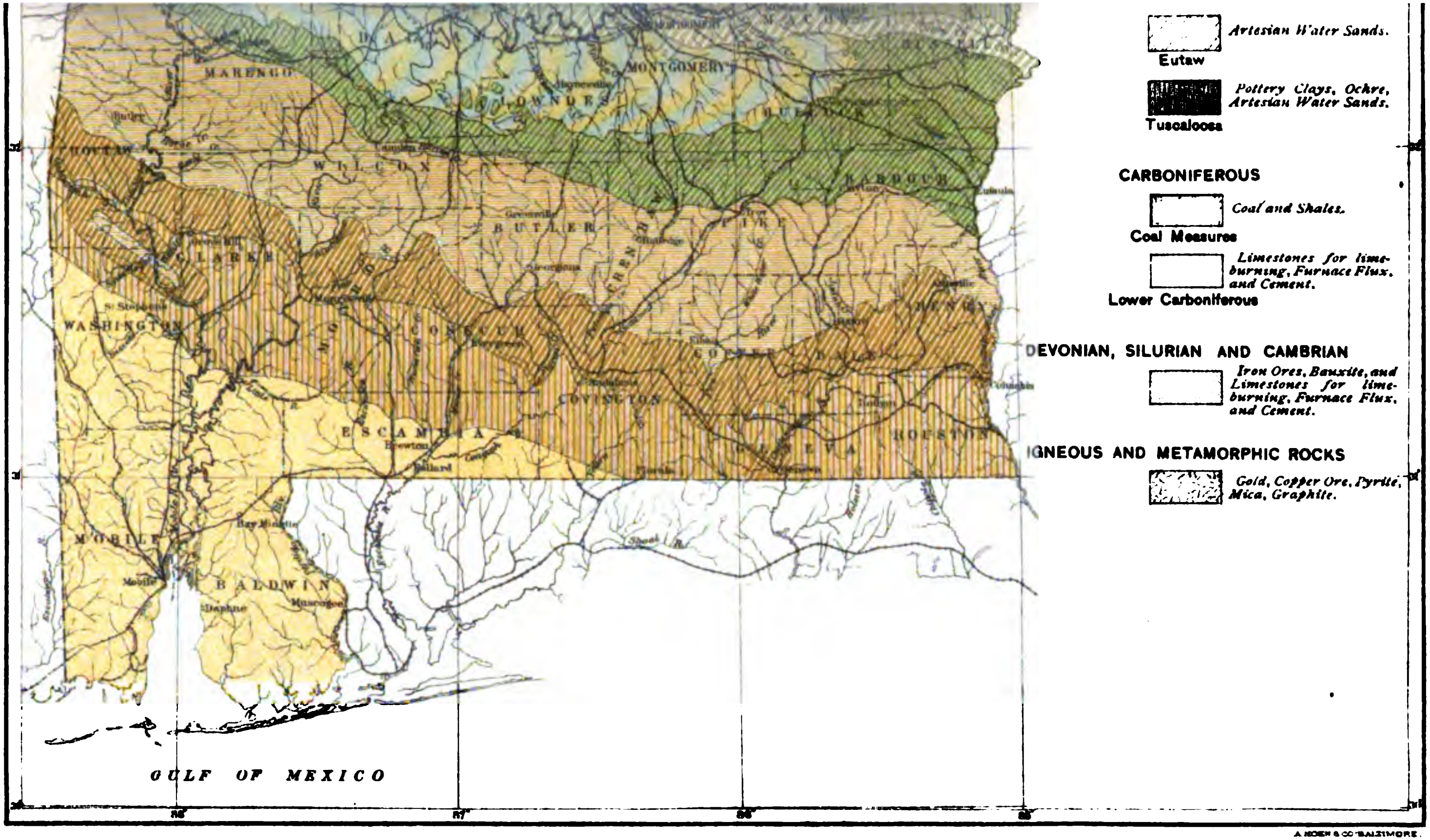

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A. HOEN & CO. BALTIMORE.

LIST OF PUBLISHED REPORTS OF THE ALABAMA GEOLOGICAL SURVEY.

1. Report of progress for 1874; On the Metamorphic Region of Alabama. Eugene A. Smith 139 pages. Out of print.

2. Report of Progress for 1875. Paleozoic Formations of Coosa Valley. Eugene A. Smith. On Coal Mining in Alabama, T. H. Aldrich. 220 pages. Postage, 5 cents.

3. Report of Progress for 1867. Paleozoic Formations of Roup's Jones', and Cahaba Valleys; Eugene A. Smith, with map; Fresh Water and Land Shells, Lewis. 100 pages. Out of print.

4. Report of Progress for 1877-78; On the Tennessee Valley, Brown's Valley, and Warrior Coal Basin; 4 county maps; Eugene A. Smith. 159 pages. Out of print.

5. Report of Progress for 1879-80. Resources of the Warrior Coal Field, between Tuscaloosa and Sipsey Fork. 2 maps. Eugene A. Smith. Tennessee Valley North of the River; Henry McCalley. 158 pages. Out of print.

6. Report for the years 1881-82. Agricultural Features of Alabama; maps and illustrations; Eugene A. Smith. 615 pages. Out of print.

7. Report on the Warrior Coal Field, 1886; Henry McCalley. 571 pages. Out of print.

8. Bulletin No. 1, Fossils of the Tertiary Formation; T. H. Aldrich and O. Meyer, 1886; 9 plates. Out of print.

9. Fresh Water and Marine Crustacea of Alabama; 8 plates; 56 pages, 1888; C. L. Herrick. Out of print.

10. Report on the Cahaba Coal Field; Joseph Squire. Appendix, Geology of Adjacent Valleys; Eugene A. Smith. Maps, 6 plates and many cuts; colored sections; 189 pages; cloth, 1890. Postage, 11c.

11. Coal Measures of the Plateau Region of the Warrior Field; H. McCalley; A. M. Gibson; map and colored sections; 238 pages, 1891. Postage, 5 cents.

12. Bulletin No. 2; On the Phosphates and Marls of Alabama; Eugene A. Smith; 82 pages; 1892. Edition Exhausted.

13. Bulletin No. 3; On the Lower Gold Belt; Wm. B. Phillips; map and illustrations; 97 pages; 1892. Edition exhausted.

14. Bulletin No. 4; Geology of Northeast Alabama and adjacent parts of Georgia and Tennessee; C. W. Hayes; map and illustrations; 85 pages; 1892. Postage, 3 cents.

15. Report on Murphree's Valley; A. M. Gibson, one section, 132 pages; 1893. Postage, 3 cents.

16. Coal Measures of Blount Mountain; A. M. Gibson; map and sections; 80 pages; 1893. Edition exhausted.

17. Geological Map of Alabama with Explanatory Chart; 1893. Edition exhausted.

18. Geology of the Coastal Plain of Alabama; Eugene A. Smith, L. C. Johnson, D. W. Langdon, and others; many sections and other illustrations; 760 pages; 1894. Postage, 18 cents.

19. Report on the Coosa Coal Field; A. M. Gibson; with section; 143 pages; 1895. Postage, 4 cents.

20. Bulletin No. 5; On the Upper Gold Belt; W. M. Brewer; with notes on the most important Rock Varieties; E. A. Smith; G. W. Hawes, J. M. Clements, and A. H. Brooks; 202 pages; 1896. Postage, 5c.

21. Report on Iron Making in Alabama; Wm. B. Phillips; 164 pages; 1896. Edition exhausted.

22. The Valley Regions of Alabama; Henry McCalley.

Part I. On the Tennessee Valley Region; 436 pp; 1896; p. 10c.

Part II. On the Coosa Valley Region; 862 pages; 1897; p. 20c.

23. Report on Iron Making in Alabama; Second Edition; Wm. B. Phillips. 380 pages. 1898. Edition exhausted.

24. Warrior Basin Report and Map; Henry McCalley; $1.00. Map in separate envelope. Numerous folding sections. 327 pages. 1900. Postage, 16 cents.

25. Bulletin No. 6; Preliminary report on the Clays of Alabama, with Chemical analyses and Physical tests of some of the more important; Dr. Heinrich Ries. 220 pages. 1900. Postage, 8 cents.

26. The Plant Life of Alabama; an account of the distribution, modes of association, and adaptions of the Flora of Alabama; together with a systematic Catalogue of the Plants growing in the State without cultivation, by Charles Mohr, PhD. Cloth. Map and two portraits. 921 pages. 1901. Postage, 33 cents.

27. Bulletin No. 7; Preliminary Report on a part of the Water Powers of Alabama, B. M. Hall. Maps and illustrations. 188 pages. 1903. Postage, 6 cents.

28. Bulletin No. 8; Preliminary Report on the Cement Resources of Alabama. Eugene A. Smith. Postage, —

29. Bulletin No. 9; Preliminary Report on the Artesian and Other Underground Waters of Alabama Eugene A. Smith. Postage, —

30. Index to the Mineral Resources of Alabama. E. A. Smith and Henry McCalley. Maps and illustrations; 79 pages. 1904. Postage, 3 cents.

These publications are mailed, free of charge; (except No. 24, price $1.00,) to Libraries and individuals who may wish to possess them; but applicants should, in each case, forward the amount of postage needed for mailing the Report desired, to EUGENE A. SMITH,

State Geologist,

University, Ala.

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CHAPTER I.

MATERIALS USED IN IRON MAKING, AND ASSOCIATED MINERALS.

It is fitting that a document which treats of the Mineral Resources of Alabama, should begin with an account of those concerned in that Industry which has done so much to give to this state its present commanding position in the industrial world, viz., Iron Making.

THE ORES.

The iron ores of Alabama in the order of their economic importance are (1) The Red Ore or Hematite, (2) The Brown Ore or Limonite, (3) The Gray Ore or Magnetite, and (4) Black Band and Clay Iron Stone. Only the two first have been mined on any large scale.

These ores are used in the manufacture of pig iron for foundries, mills and pipe works, and for making basic iron for open hearth steel plants. As a rule, they are too high in phosphorus for making Bessemer steel.

Practically all the ore mined in Alabama is smelted in the state, the shipments out of the state being about equal to what is received from other states.

Alabama stands third in iron ore production among the states of the Union. The product for 1902 was 3,574,474 long tons, which was a little over ten per cent. of the iron ore mined in the United States. This output had a value at the mines at $1.10 per ton, of $3,936,812. This valuation is less than that obtaining in any other state except Texas, the average in the United States being about $1.84 per long ton.

There are 42 coke furnaces and 6 charcoal furnaces in operation in the state. The charcoal furnaces are gradually going out of blast, and will soon be a thing of the past.

In pig iron production Alabama ranks fourth among the states of the Union. This high rank, which will probably soon be exceeded, is due in great measure to the close proximity of the ore, the stone, and the coal needed for the production of the iron. At many points in the Birmingham District these three essentials are obtained within a radius of six miles of the furnaces.

(1.) RED ORE, OR HEMATITE:—While Hematite occurs in Alabama in several geological formations, it is only in the Upper Silurian that it is in sufficient quantity to be of great commercial value. This, the Red Mountain, or Clinton ore, is otherwise known as Dyestone ore, Fossiliferous ore, Oolitic ore, etc. It is the most important iron ore in the state because of its great quantity, the low cost with which it may be mined, its reliability, and its close proximity to the coal and stone used in the manufacture of iron. The output of red ore for 1902 was 2,565,635 long tons, making about 72 per cent. of the iron ore product of the state.

The Red Mountain ridges occur normally on each side of the anticlinal valleys which separate the Coal areas from each other, and are distinguished as East Red Mountain and West Red Mountain. In places the red ore ridges are lacking on one side of the valleys, usually the western side, being cut out by faults, while on the other hand the ridge may be duplicated on one side by the same cause. This *formation* occurs also in the much disturbed strata east of the Coosa Coal Field, in ridges of sandstone and conglomerate which carry no red ore.

In most of the valley occurrences, the moderate dips of the strata are on the eastern side, and the steep dips and faults are on the western side. Murphree's Valley makes an exception to this, the faults and vertical measures being on the eastern side. It is usually the case also that the ore bed shows the highest angle of dip at the outcrop, and that the dip rapidly decreases as the bed is penetrated.

The iron occurs mainly in the central part of the formation, in seams or beds, one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop, which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in by far the greater part of this distance.

Plate I—Outcrop of Red Mountain Ore Seam, at Ishkooda, Jefferson County

Much mining of red ore has been done near Gate City. Village Springs, Springville, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head. etc., but the most important development of the Clinton ore in the state and in the world, is along the 15 or 16 mile stretch of the East Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines, and strippings for this entire distance. The ore here is in three different seams, but the upper fifteen feet of the *Big Seam* or *Red Mountain seam*, have furnished almost the entire supply of ore to the 23 furnaces of the district.

Plate I shows the outcrop of this seam near Birmingham.

In a large part of this stretch of Red Mountain, the ore has been gained by stripping down to where the cover becomes fifteen or twenty feet thick over the ore and too expensive to remove.

Most of the ore, however, is obtained from well developed deep mines going down on the slope of the bed. These mines are equipped with all the latest and most improved devices for the cheap handling of the ore. The deepest of these mines at the present time has gone down on the dip of the bed a distance of 1850 feet from the outcrop. The ore is brought by small mine cars from the different entries to the main slope and there emptied into a skip holding from 12 to 14 tons. The skips are hauled to the surface by steam power, the ore is dumped automatically into the crushers and thence into the railroad cars. This arrangement very greatly increases the handling capacity, and is intended to work to a depth of about a mile. When fully equipped the Red ore mines of the Tennessee Coal, Iron and Railroad company alone will have a capacity estimated at 10,000 tons a day.

The ore of the Big Seam improves in quality towards the southwest, the percentage of lime increasing while that of silica decreases. The percentage of alumina remains about constant, but on account of the coming in of slate partings, more care has to be exercised in the mining.

The lower and major part of the Big Seam has not been worked except very sparingly at the outcrop, being too siliceous, with the silica increasing from top to bottom of the seam.

Experiments carried out by Dr. Wm. B. Phillips for the Tennessee Company, have fully demonstrated the practicability of reducing the relative proportion of silica by magnetic concentration, so that the entire thickness of this great seam will one day be utilized, and the same may be said of the siliceous ores of other parts of the state.

The other seams of the Red Mountain Ore, viz., the *Irondale Seam* below the Big Seam, and the *Ida seam* above it, have been worked at places along the East Red Mountain from opposite Birmingham towards the northeast; the ore is softer than that of the Big Seam, carrying sometimes over 50 per cent. of metallic iron. The Ida seam, where worked, yields a compact ore five or six feet thick, with 30 to 35 per cent. of metallic iron.

In most of the smaller mines the mine cars are hauled to the surface; the miners are paid by the car load (about two tons), the tracks being kept up by the company.

Without any reference to the actual hardness of the ore, the leached red ore containing very little lime is called *soft ore,* and the unleached or limy ore, *hard ore.*

The soft ore is usually hard enough to necessitate blasting and crushing. As a rule it extends down on the dip a distance of 150 to 200 feet from the outcrop, though on the one hand it sometimes extends 300 feet, and on the other hand, in places the hard ore sets in at the outcrop; the amount and depth of the soft ore apparently being more or less determined by the cover. The transition from the one variety to the other is usually abrupt, but the line of contact is irregular, the soft ore extending in points down into the hard ore. Moreover, the soft ore often includes boulders and pockets of the hard ore, and occasionally "horses" of ferruginous sandstone. Both ores are quite contsant in composition away from the line of contact.

The *soft ore* is limited in quantity but this does not signify much, is it is being less and less used in the furnaces. It is usually a mass of smooth, rounded, and flattened grains of quartz of the size of bird shot and smaller, coated with hematite and cemented together by the same material. Its average composition as shown by stock house analyses extended over many years, is about as follows: Silica or insoluble matter 27 per cent; Metallic iron 46 per cent; Water 7 per cent; Phosphorus 0.30 per cent. to 0.40 per cent. and a little lime.

The main dependence of the furnaces of the Birmingham district is the *hard ore*. In the mines it always sets in at the water level, holding its own as to thickness and composition, to the bottom of the deepest mine, 1850 feet, and as far as tested by borings, at least 3,500 to 4,000 feet to the southeast from the outcrop; there seems thus to be no reason for anticipating any adverse change in the ore within the depth to which mining operations are likely to be carried.

When the hard ore carries about equal amounts of silica and lime it is self-fluxing, and under these conditions it has been used alone in the furnaces. Usually, however, it contains more lime than is necessary for self-fluxing, in which case, a little soft ore, or brown ore, or both are added.

At the present time the soft ore makes seldom over ten per cent of the ore burden, though in some of the furnaces it makes half of the burden. From stock house samples the composition of the hard ore is shown to be about as follows: Silica, 13.4 per cent.; Metallic iron, 37 per cent.; Lime, 16.20 per cent.; Alumina, 3.18 per cent.; Phosphorus, .37 per cent.; Sulphur, .07 per cent.; Carbonic acid, 12.24 per cent.; Water, 0.50 per cent.

Red Hematite occurs in Alabama also in the Trenton formation, where it is very similar in quality and appearance to the soft red ore of the Clinton. And in the Cambrian formation still lower in the geological column, it has been observed in stratified seams from 18 inches to 5 feet in thickness.

The Cambrian ore is of the crystallized or specular variety, and may some day be utilized. The known occurrences of it are few in number and none of them has as yet been fully tested.

(2.) Brown Ore or Limonite. — This ore, the second in importance of the iron ores of Alabama as well as of the United States, furnished only 9.3 per cent of the total iron ore production of the United States in 1902. Of this, Alabama produced 28 per cent, 1,008,839 long tons, and the state leads in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the state. It was then demonstrated

that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted. Usually the brown ore constitutes about 20 per cent of the ore burden. This addition of brown ore to the red, besides taking care of the excess of lime in the hard red ore, causes a smoother and more uniform flow in the furnace burden, lessening the danger from hanging or shelving.

In a few places a manganiferous limonite occurs, and small quantities of it have been used in the production of spiegeleisen, and ferro-manganese.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank. The mining is in irregular diggings and open cuts, and is mostly done by contract, costing about 75 cents on an average to mine, and bringing about $1.00 per ton at the furnace

Among the varieties of brown ore are the compact, the honey comb, and the ochreous or earthy ores. The pocket ore is

nearly always associated with "horses" of clay often pure white and plastic. It is also sometimes mixed with foreign matters such as loose chert, and fragments of sandstone and conglomerate.

The deposits occur in nearly all the geological formations of the state, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur in the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally, occur also on the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The Lafayette.—This ore is widely distributed, but does not occur in many places in sufficient quantity and of such quality as to justify working. It is the principal ore of the northern part of the state in the counties of Colbert, Franklin, Marion and Lamar.

Loose boulders scattered over the surface supplied the first furnace in Alabama, which was built in 1818 on Cedar Creek in Franklin county. A Catalan forge must also have been at the same place for lumps of malleable, as well as of cast iron, are to be found around the old furnace ruins.

The furnaces of Sheffield and Florence use this ore without admixture with other ore. Many of the deposits are on high ground and are comparatively shallow, as shown by the diggings extending down to the underlying bedded rocks. Other deposits in lower situations are 50 and 60 feet and more in depth. The ore is mostly a dark colored compact ore, but in in some of the deposits it is of concretionary nature with red and yellow ochres filling the cavities. It occurs in a red sandy loam usually along with rounded pebbles of quartz and often with ferruginous sandstone and conglomerate. This ore, while occurring in the surface red loams of the Lafayette, probably has its source in the Lower Carboniferous limestones and possibly also in part in the stratified seams at the base of the Coal Measures.

In the banks the ore often makes 25 to 30 per cent of the entire mass. It is of good quality as is shown by the following average analysis of washed ore furnished to the Sloss-Shef-

field furnaces from the numerous banks about Russellville: Metallic iron 53.67 per cent; Alumina 5.58 per cent; Silica 8.52 per cent.; Phosphorus, 0.33 per cent. It is said to work well in the furnace and to yield an unusually good quality of pig iron, that seldom runs higher than 0.60 per cent of phosphorus and 0.50 per cent of silicon.

The Lauderdale Chert:—The ore of this formation is in stratified seams and pockets. The former are probably the weathered outcrops of carbonate and the pocket ore also, in part at least, from the weathering and breaking down of the stratified seams.

The stratified ore in one or two seams may in some localities be traced for miles where it is too thin or too cherty to be of commercial value. At intervals along these outcrops there are some extensive deposits of boulder, nodular and gravelly ore of good quality, though as a rule inferior to the limonites of some of the other formations. It has never been extensively worked in Alabama. Some of the limonites of this formation are highly manganiferous.

The Knox Dolomite:—The brown ore of the Knox Dolomite is the most abundant, has been extensively mined and, in general, is the best of the iron ores of the state. Some of the deposits have been worked to depth of 100 feet with ore still at the bottom.

The most important deposits and mines are in Cherokee, Calhoun, Talladega, Shelby, Bibb, Tuscaloosa and Blount counties. The ore is found in irregular pockets in the red clay resulting from the decomposition of the limestone of the formation, and while mostly of good quality, high in iron and low in silica and phosphorus, it is sometimes rough and cherty and sometimes a black waxy ore, high in phosphorus. The cherty ore is usually in large boulders, sometimes occurring in rows as if outcrops of stratified ledges.

The view in Plate II of an open cut at Greeley in Tuscaloosa county, illustrates well the mode of occurrence and method of mining the brown ore.

The average composition of the dried ore, as shown by many analyses is, Metallic iron 51.00 per cent; Silica 9 per cent; Alumina 3.75 per cent; Lime 0.75 per cent; Phosphorus 0.40 per cent, and Sulphur 0.10 per cent.

Plate II.—Greely Open Cut Brown O

line, Goethite, Tuscaloosa County.

The charcoal furnaces of the state are wholly supplied with this ore.

The Weisner Quartzite:—The deposits of this formation are numerous and extensive, and are either the outcrops of one or more stratified seams, or a pocket ore derived in part at least from the weathering and breaking down of the stratified seams.

The stratified ore outcrops near the crests of the mountains, (Weisner), while the pocket deposits are mostly near the base of the mountains or along fault lines. The former deposits are very variable, attaining sometimes considerable size, being as much as several hundred yards in length and forty to fifty feet thick. The pocket ore comprises some of the most extensive brown ore deposits in the state. The ore itself is somewhat variable, being in part a black waxy ore high in phosphorus, in part a mixture of very good ore with a highly siliceous or sandy ore.

For this reason the mining is sometimes tedious and expensive because of the necessity of separating the good from the bad. These siliceous or sandy ores are in very large quantities and will no doubt some day be utilized after being concentrated by magnetic process.

(3.) THE GRAY ORE OR MAGNETITE:—This ore occurs in the upper part of the Weisner Quartzite formation in Talladegt county. It is in several stratified seams, one to four, varying in thickness from two to eight feet.

While these seams of ore are generally highly siliceous and hardly more than dark gray sandstone with sparingly disseminated grains of magnetite, yet in places the ore carries as much as 80 per cent of magnetite and only 17 to 18 per cent of silica.

The ore is sometimes massive in structure sometimes laminoted and almost fibrous, breaking up on weathering into fragments that resemble chips of wood. The magnetite is also sometimes in thin scales or plates making a kind of specular ore high in titanium.

The Talladega magnetite has been somewhat extensively investigated and considerable amounts have been raised and furnace tests made, and it is probable that this desirable ore will soon be added to the list of our commercially important resources.

Considerable magnetite has been observed at a number of points in the region of our metmorphic rocks, but as yet not in sufficient quantity to be commercially used.

(4.) BLACK BAND AND CLAY IRON STONE:—The black band is a highly carbonaceous variety of the carbonate ore, occurring at a number of points in the Coal Measures. It has been mined or quarried at only a few places and then only to a very limited extent. Some experiments have been made with it in the furnaces both in the raw and calcined state.

The Clay iron stone occurs in regular seams and in rounded and flattened concretions in the strata of the Coal Measures, and also in the lower Cretaceous and in the Tertiary formations, in none of which, however, has it yet been demonstrated to be of any commercial importance. As result of the weathing and disintegration of this ore are found occasionally some very good deposits of limonite or brown ore.

In connection with iron ores two closely associated minerals may appropriately be described, viz., manganese ores and bauxite.

Manganese Ores.

Pyrolusite and Psilomelane occur in a number of localities in Cleburne, Calhoun, Blount and Cherokee counties in quantity sufficient to make them of probable commercial value.

Several of these deposits in the Weisner formation in Cleburne county have been worked and have furnished probably the greater part of the pure manganese ore that has been mined in the state.

Manganiferous limonite has been mined to some extent near Anniston and converted into *spiegel eisen* and *ferro-manganese* in the Anniston furnaces.

In its mode of occurrence manganese ore is very similar to brown iron ore, with which it is closely associated, most of the brown ore banks containing more or less of it, and it often happens that the same deposit is partly limonite and partly manganese ore. The Blount county deposits of this kind are near the base of the Fort Payne chert of the Lower Carboniferous, those of Cherokee, Tuscaloosa and other counties are in the Knox Dolomite.

Bauxite.

This ore, a hydrate of alumina, is much used as a source of the metal aluminum and of some of its compounds, mainly alum. In this state it occurs, mainly in the Knox Dolomite and in the Weisner Quartzite formations, in irregular deposits along a narrow belt extending from the Georgia line southwestward as far as Anniston. All the deposits thus far known are in the counties of Cherokee, Cleburne, Calhoun and DeKalb, but they are too irregular in their occurrence and have been too little investigated to admit of any close approximation to the quantity of the ore.

The ore is commonly concretionary or pisolitic though sometimes compact, homogenous and fine grained, and the best quality is of gray to white colors. Much of it has iron oxide replacing part of the alumina with the result of giving a reddish and mottled appearance to the ore.

Associated with the true bauxite are mixtures of clay and bauxite in varying proportions, and in places irregular streaks or bands of pure halloysite occur in the midst of the bauxite. The bauxitic clays above mentioned are exceedingly refractory and have been suggested as suitable material for the manufacture of fire brick.

The mode of ccurrence of the bauxite is very similar to that of limonite, in irregular and ill defined pockets, and in some of the limonite banks about Rock Run in Cherokee county, the iron ore appears to grade into the bauxite, and both ores have been obtained from the same digging. Other associations with the bauxite are white china clay and lignite, both of which occur in a bauxite-limonite bank near Rock Run. Manganese ores have also been observed in connection with the bauxite.

The bauxite is obtained from open cuts and pits which are in places 60 to 70 feet deep. It is easily mined, being rather soft below the surface. After sorting and concentrating by screen and hand, it is spread out under shelter and dried by artificial heat before sending to the market, rotary driers being most commonly used. Only the very highest grade of the ore is sold, the lower grades being thrown aside for the present, but the time will probably come when it will all be used in the manufacture of fire brick, as well as of aluminum compounds

of various kinds. In the year 1903 only about 6,262 long tons of bauxite were mined in Alabama, as the works were mostly in that part of the deposit lying within the Georgia line. The principal markets are New York, Philadelphia, Pittsburg, Buffalo, Syracuse, Lockport, etc., where are located the aluminum and alum manufactories; and some of the best quality was exported to Germany.

Fuller details concerning the iron and manganese ores and bauxite may be found in the Reports on Murphree's Valley, and on the Valley Regions, Parts I and II, and in the report of Iron Making.

THE COAL.

The termination towards the southwest of the great Appalachian Coal Field, embraces an area in Alabama of about 8,800 square miles.

This area is in three distinct fields separated from each other by narrow anticlinal valleys in which the limestones, iron ores, etc., of older formations than the Coal Measures make the surface. From the main streams which drain them, these fields have been named the Warrior, the Cahaba and the Coosa.

In all three fields the strata have a general dip or pitch towards the southwest, and each is a trough with its axis near the southeastern border; thus the greatest thickness of the measures will be in each field, near the eastern border and at or towards the southwestern end.

The maximum thickness of these measures will not fall short of 4,000 feet. The coal seams vary in thickness from a few inches up to 16 feet, but the thick seams are always more or less shaly. About 25 of these seams have a thickness of 18 inches upwards and have been worked.

Previous to 1874 it has been estimated that the total coal production of Alabama did not exceed 480,000 tons, the earliest mining operations having been carried on in the "forties," in the Trout Creek and Broken Arrow regions of the Coosa field, and in the Montevallo district of the Cahaba field. Since 1874 the production has increased rapidly and in 1903 it was, according to the report of the State Mine Inspector, 11,700,753 tons, valued at about $15,000,000, Alabama ranking fifth among the coal producing states of the Union.

Between two hundred and fifty and three hundred mines on about twenty-five different seams have furnished this coal. These mines vary in annual production from 2,000 to 418,000 tons; more than half of them are drifts with natural drainage; about one third are slopes, and only seven are shafts, the deepest of which is 230 feet. The larger mines are provided with the most modern equipments for mining and raising the coal. The pillar and stall system is the mining method most in use, but the long wall system has been adopted in some cases.

In the year 1903 coal mining gave employment to 12,876 miners and 5,230 day men, using about 100 mining machines in 13 mines. The mines are comparatively free from fire damp which has been detected in about one fourth of them.

The Alabama coals are all bituminous coals, and of quality, as shown by chemical analyses and the practical tests of use, to compare favorably with the coal of other states. By the use of improved shaking screens the coal as mined is separated into lump, nut and slack. The two first go to the general market for steam and domestic purposes, while the slack after washing is used mostly for making coke for the iron furnaces, though some of it is used for blacksmithing. Within the last few years a good deal of *run of mines* from several different mines has been shipped to Demopolis and there used in the rotary kilns of the portland cement plant, for which purpose it has been found to be well adapted.

The principal markets for the coal are within the state, but much of it goes to South Carolina, Georgia, Tennessee, Missippi, Louisiana and Texas; to the steamships at Mobile, Pensacola, New Orleans and Savannah; and to the export trade, chiefly to Mexico.

The home supply is used mainly for manufacture of coke for the iron furnaces, while the commercial shipments are mostly of steam coal which is suplied to almost every railroad in the South.

The growth of the Coke industry in Alabama has been even more rapid than that of the coal mining. It was not until 1876 that it was known that the Alabama Coal would make coke suitable for iron smelting, and the state ranks now second in the Union as a coke producing state.

The coke production in 1903, as given in the Alabama State Mine Inspector's Report, was 2,568,185 tons. The

greater part of this coke was used in the iron furnaces of the state, though a portion of it was shipped to other states and to Mexico, for smelting and foundry purposes. The present product does not begin to supply the demand and many new ovens are in course of construction. The coke in 1903 was made in about 8,638 ovens, all of the bee hive pattern except about 240 Semet-Solvay ovens at Ensley, with a daily capacity of about 1,250 tons.

The 80 Semet-Solvay ovens at the Central Furnace near Tuscaloosa were not yet in operation in 1903.

Most of the coke is made from slack coal but the entire output of some of the mines, after crushing, washing and draining, is converted into coke. With one or two exceptions, the heat and gases from the bee hive ovens are allowed to go to waste; but the Semet-Solvay ovens, of course, utilize these products.

At a valuation of $2.45 a ton the coke product of Alabama during 1903 was worth nearly $6,000,000.

The Warrior Coal Field.

This field which lies to the north and west of the other two above named, has nearly ten times the area of the two combined, estimated at 7,800 square miles. In the usual classification the Warrior Field comprises all of the coal measures of Alabama, drained by the Warrior and Tennessee Rivers, together with those of Lookout Mountain drained by the Coosa river.

The relatively greater importance of the Warrior Field is due also to the vast amount of coal that can be economically mined within its limits, the coal seams outcropping over great areas and with very moderate angle of dip.

For convenience of description the Warrior Field has been divided into the Plateau Region and the Warrior Basin.

The *Plateau Region* includes the northeastern part of the Field, approximately from the line of the L. & N. railroad to the Georgia and Tennessee borders, together with the spurs of the great Cumberland table land on the western and northern side of the Tennessee river. The name comes from the circumstance that the uplands or mountains are portions of the original elevated table land or plateau into which the valleys

have been cut to the depth of 600 to 800 feet. The altitude of these uplands varies from 1200 to 1800 feet above tide water in the northeastern part, to 700 or 900 feet in the vicinity of the L. & N. railroad. The Coal Measures which take part in the formation of these uplands are the strata between the Black Creek Coal Seam and the base of the Coal Measures, embracing about 1800 feet thickness. This full thickness of the plateau measures, including 15 or more seams of coal, occurs along the southern limits of the Plateau region where it merges into the Basin, while near the northern edge adjoining Georgia and Tennessee, there are only about 200 feet of coal strata including one or two coal seams. It will thus be seen that the strata dip towards the southwest at a more rapid rate than does the surface of the country, and the coal measures thicken proportionally in the same direction. The coal seams in the Plateau region are very variable in thickness occurring in bulges and squeezes. Where the strata are thick enough to carry them only about four of the coal seams appear to be always present, only about six of them ever to be of workable thickness, and only two of them of workable thickness in most of their outcrops. In general these plateau coal seams are thickest and most reliable in the northeastern part of this region near the Georgia and Tennessee lines. The coal is usually good, hard, and solid, though sometimes carrying considerable pyrites. Mines have been opened on these seams at a number of places, but the want of uniformity in thickness has prevented any extended operations. In 1903 the production from this region was only about 17,500 tons. These lower seams have furnished all the coal mined in Tennessee and Georgia.

The *Warrior Basin* includes the larger, southeastern part of the field extending in general from the line of the L. & N. Railroad down to where the coal measures pass finally below the Cretaceous formations and appear no more at the surface. As has already been said, the strata dip more rapidly towards the southwestern end of the field than the surface of the country falls away, and the greatest thickness of the measures in consequence is to be found in the southwestern part of the area, in Tuscaloosa county.

The Coal Measures of this region include the strata from the Black Creek coal group to the top of the measures, about 2,-

000 feet, and they contain six groups of coal seams, which, in ascending order, are as follows: the Black Creek group with three seams; the Horse Creek group with five seams; the Pratt group with five seams; the Cobb group with three seams; the Gwin group with two seams; and the Brookwood group with five seams. The seams of a group are seldom more than 25 feet apart, while the groups themselves are usually separated by 200 to 300 feet or more of barren measures. Of the 23 seams above mentioned, 21 have in some of their outcrops a thickness of at least two feet, and may be considered workable. The thickness of the seams varies from a few inches up to 16 feet, but as usual, the thicker seams are more or less shaly. The Warrior Basin furnished in 1903 nearly 10,500,000 tons of the total product, obtained mostly from the seams of the Brookwood, Pratt, Horse Creek, and Black Creek groups, the Pratt and Horse Creek groups furnishing by far the largest proportion. The mines are in nine different counties, Jefferson county alone supplying about 6,250,000 tons, or nearly half the total output of the state. Of the 235 mines, 166 are drifts; 63 are slopes, and 6 are shafts.

Most of the coal of this basin is free burning and good both for steam and domestic purposes and for coking. From the coal of this basin about 2,621,000 tons of coke were made in 1903. As a rule the coal of the Warrior field has a jointed structure by reason of which it breaks into cubical or rhomboidal blocks, though some of it is hard and compact and devoid of this structure. Mineral charcoal is common in the coal of some of the seams, especially west of the Warrior River.

The accompanying view, Plate III, shows a section of the Blue Creek Coal seam of the Horse Creek group, at one of the mines of the Tennessee Coal & Iron Company, in the Little or Blue Creek Basin of the Warrior Basin.

The Cahaba Coal Field.

This is the middle one of the three Alabama Coal Fields. Its length from northeast to southwest is 60 to 70 miles and the width of the upper part about five or six miles, but it widens out towards the southwest, and below the line of the L. & N Railroad it has a width of 12 or 15 miles; the area embraced is about 400 square miles.

The northwestern border of the field is made by the escarpment of Shades Mountain overlooking Shades Valley; the southeastern boundary is a fault of 10,000 feet displacement, by which the Cambrian strata are brought up to the level of the Coal Measures. Along the southern border of the field from Montevallo westward, this fault has overturned a narrow strip of the measures, including several seams of coal.

In structure this field is an unsymmetrical synclinal with its axis very close to its southeastern edge. As a consequence most of the strata of the field have a dip to the southeast almost to the edge of the field, the structure seems to be monoclinal, and the greatest thickness of measures is very close to the eastern border. The wider part of the field, to the southwest of the L. & N. Railroad, is divided by an interior faulted anticlinal which separates the Blocton Basin on the west from the Montevallo and other basins on the east. Minor warpings of the strata have broken the field up into a number of smaller basins.

As with the Warrior Field, so here, the general dip of the field as a whole is to the southwest, and at this end of it we find the greatest thickness of the measures aggregating some 5,500 feet, and holding 50 or more coal seams, half of which have in places a thickness of 2 feet and upwards.

The Maylene basin north of the Montevallo appears to have the topmost measures, and consequently the greatest thickness.

At the present time mining operations are practically confined to the wider southern end of the field beyond the line of the L. & N. railroad, the principal center of production being in the vicinity of Blocton, where at least a dozen mines are in active operation, the Thompson seam being the one mainly worked. East of the interior fault and the measures immediately adjacent to it, much mining is also done in the Montevallo and Maylene basins on the Montevallo and Maylene seams, and along the Southern Railroad also at Glen Carbon, and near Helena on other seams.

The mines of the Cahaba field furnished in 1903 1,781,078 tons of coal. This coal was mined from eight different seams and nineteen mines, eighteen of which were slopes, and one a drift.

As a general rule, the Cahaba coals are of excellent quality. Some of them are the finest steam and domestic coals in the state, and from some an excellent quality of coke is made. The

coal of the Cahaba field is in general somewhat harder and cleaner than the Warrior coal, and it is exported to Mexico and South America in large quantities.

THE COOSA COAL FIELD.

This, the smallest, least known and least productive of the coal fields of Alabama, lies to the east of the other two. Like the Cahaba field, it is long and narrow, being sixty miles in length, with an average width of less than six miles, and an area of over three hundred square miles. The southwestern end, like the southwestern end of the Cahaba field, is separated into two parts by a narrow faulted anticlinal valley. The northwestern border of the field is a high mountainous escarpment. The eastern border is made by a fault, which brings Silurian strata up to the level of the Coal Measures. The general dip of the field, as in the other two, is towards the southwest, and the field is an unsymmetrical anticlinal, with its axis close to the eastern edge. We find, therefore, the thickest measures along the eastern edge of the field, and towards its southwestern extremity. It is not easy to determine the thickness of the measures included in the Coosa field, but it is less than in either of the others. The general dip of the strata above mentioned is interrupted at intervals by minor undulations, which have broken the field up into a number of somewhat independent basins. Some seventeen or eighteen seams of coal have been identified in this field, seven or eight of which have in places a thickness of two feet and more. The thickest and most important of these seams occur near the eastern border of the field, and do not underlie very much territory. Mining operations have been carried on mainly at two points, namely, Ragland and Coal City. The output of the field for the year 1903 was 121,000 tons. The coal is remarkably pure, free from dirt and pyrite, and whilst not so hard as the Cahaba coal, is excellent for coking. Some of the earliest mining in the state was done at the two points mentioned.

Those interested will find in the following Reports, published by the Geological Survey, further details concerning the several coal fields:

On the Plateau Region of the Warrior Field; by Henry McCalley.

On the Warrior Basin, by Henry McCalley.

On the Cahaba Coal Field, by Joseph Squire; On the Coosa Coal Field, by A. M. Gibson.

THE STONE.

Limestones and Dolomites.

These rocks which are used for furnace flux and for lime burning are to be found in Alabama in sufficient quantity to satisfy every demand that will ever be made on them.

The fluxing rocks in all the furnaces of the state were exclusively limestones until a few years ago, when dolomite was found to be well adapted to the purpose, and it has since come into very general use in the Birmingham district, where it exists in very convenient proximity to the furnaces. The dolomite as a rule, is of more uniform composition and freer from silica than the limestones, that used in the Birmingham furnaces holding on an average not more than 1.5 per cent. silica, while the limestone will generally average 3 to 4 per cent. The dolomite is therefore better for the making of low silicon pig iron. The purest of the limestone beds are however purer than the best of the dolomite, but the interstratification of ledges of varying quality necessitates much careful selection in quarrying.

The use of limestone as a flux is now again on the increase because of demand for the slag for cement making.

Dolomite.—The most important horizon of the dolomite is the Knox Dolomite of the Cambrian, while the limestones belong mostly to the Trenton of the Lower Silurian and to the Mountain Limestone division of the Lower Carboniferous. All of these have been very extensively quarried to supply the furnaces.

The *Knox Dolomite* as a formation is from 2,000 to 5,000 feet in thickness, the lower part containing some beds of exceedingly pure dolomite, while in the upper part this dolomite is very much intermixed with chert.

The rock used as flux is mostly coarse grained, light gray to dark blue in color, and more or less crystalline in texture.

Dolcito quarry, near Birmingham, is one of the largest in the state, having a capacity of 2,000 tons a day. At the present time it is some 300 yards long and nearly 100 feet in depth at the deepest part. It shows a number of ledges which carry less than 1 per cent. of silica in car load lots.

About one car load a day of selected lump from these ledges is sent to the Ensley Steel Works to be used instead of magnesite in the lining of the furnaces.

The accompanying view, Plate IV, shows the condition of this quarry in 1900.

Other large quarries in the Dolomite are in the immediate vicinity of North Birmingham.

The dolomite from this formation is not used in lime burning though it would no doubt make an excellent lime, as is shown by the lime made of a crystaline dolomite at the Chewacla lime works, in Lee county, near Opelika, where the dolomite of unknown geological age is associated with metamorphic rocks.

Limestone.—The most extensively quarried limestone is that occurring in the Lower Carboniferous formation and generally known as the *Mountain Limestone.* In the northern part of the state this rock is 350 to 1,300 feet in thickness, and covers a great area. In the southeastern part of the region of their occurrence these limestones become very slaty and sandy.

The purer portions of this limestone carry from 95 to 99 per cent. carbonate of lime, but with the better quality of the rock, shales are often interstratified and in the lower part of the formation, the limestone is highly siliceous and of dark blue color.

The Mountain Limestone, as the name indicates, often occurs on mountain sides above drainage level, and therefore in position admirably situated for extensive and cheap quarrying. The principal quarries are near Blount Springs and Bangor on the L. & N. railroad, and near Trussville and Vann's on the A. G. S. railroad.

The *Trenton* or *Pelham Limestone* of the Silurian is another great limestone formation which has been much used both as flux in the furnaces and in lime burning. This limestone occurs in long narrow belts on the flanks of the Red Mountain ridges on each side of the anticlinal valleys. Sometimes it lies in the valley at the foot of the mountain, sometimes it occurs

Plate IV—Dolomite

y at Dolcito, Jefferson County.

high up on the side of the mountain and at times even up to the summit. The rock in its best quality is a compact blue limestone, often highly fossiliferous. Weathered surfaces are frequently marked with furrows called "karren felder" which resemble the furrows which one makes by drawing the outspread fingers over a soft surface of plastic clay. These marks are caused by the dissolving action of the little rills of rain water running down the exposed surface.

The best part of the rock is comprised within the uppermost 200 feet of the formation, the purest ledges carrying from 95 to 98 per cent. of carbonate of lime. With these ledges, however, are interstratified others of less desirable composition.

Some of the quarries on the sides of the mountains show clear faces of the stone 100 feet in height, and hundreds of tons can be thrown down by a single blast. These quarries have all the conveniences of situation above the crushers and railroad tracks, and are admirably located for large production at small cost. One extensive quarry is that of the Sloss-Sheffield company near Gate City.

For lime burning this rock has probably been more extensively used than any other in the state, supplying kilns at Pelham, Siluria, Hardyville, Genadarque, Longview, etc., in Shelby county for the manufacture of the long celebrated "Shelby Lime."

In this connection we may speak of other forms of limestone capable of industrial application, viz., marbles and lithographic stones.

Marbles.

The marbles of Alabama are of two kinds, crystalline or true marble, and non-crystalline.

The *crystalline* or *statuary marbles* occur mainly in a narrow valley along the *western* border of the Metamorphic rocks, extending from the northwestern part of Coosa county through Talladega into Calhoun. The outcrops have a width of about a quarter of a mile and a length of 60 miles at least.

The best as yet known are in Talladega county, and the principal quarries from which the stone has been obtained are in the vicinity of Sylacauga, and near Taylor's Mill, on Talladega Creek. At a number of places within these limits, before

the civil war, marble was quarried and worked into monuments chiefly. Since the war very little has been done in this line. The quarries were not sunk to any considerable depth (25 feet) and it is doubtful if any of them has gone below the reach of weathering.

In some places the marbles are defective from streaks of talc and a kind of slaty cleavage, but many fine blocks have been obtained and worked up.

A stone from Gantt's Quarry was presented by the Masons of Alabama to the Washington Monument Society in 1851 to be incorporated in the monument. The quality of the marble was such that it was believed by many to have come from Italy. During the present year the Italian sculptor Moretti, who has designed and modeled the Alabama iron colossus, "Vulcan," has obtained some beautiful granular marble from Talladega, which he has wrought into a number of pieces of statuary which will be on exhibition at the St. Louis Exposition.

There is now in Birmingham from Talladega a block of white marble, 30 feet in length and 3 feet wide and 2 feet thick.

In composition most of this marble is quite pure lime carbonate (97 per cent.) and it has been used as furnace flux in one of the iron furnaces.

Along the *eastern* foot of the Talladega mountain range also there are two places where a crystalline dolomite has been observed, viz., in Chilton county on the banks of the Coosa river and in Coosa county immediately opposite and up the banks of Paint Creek. The other locality is near Elder postoffice, in Clay county. Nothing has been done at either of these localities in the way of developing the stone.

Still further southeast in Lee county near Opelika there is a quarry in white crystalline granular dolomite which has been worked for a great many years for making lime. This is the Chewacla lime works and quarry. This same deposit has been traced for a number of miles both northeast and southwest of the Chewacla quarry, and the stone has been obtained and used in lime-burning at Echols Mill, at Springvilla, etc., but at this time only the Chewacla works are in operation. This stone, while of beautiful white color and granular texture, has in some of the ledges, small streaks of talc also of white color, which would seriously interfere with its use for ornamental purposes. It is probable that some of the ledges are free from this defect.

The *non-crystalline marbles* occur in most of the limestone formations of the state. Under this term we would include those compact limestones which take a good polish and which have an agreeable color and which can therefore be used for ornamental purposes. Rock of this kind has been utilized from the Cambrian formation, from the Trenton, from the Lower Carboniferous, and from two horizons in the Tertiary, viz., at the base in the Midway or Clayton division, and higher up in the St. Stephens limestone.

The Trenton and Cambrian limestones are often beautifully variegated in similar manner to the Tennessee marble. Handsome blocks of this quality have been cut and polished from near Calera, from Pratt's Ferry on the Cahaba River, and from Jones Valley between Bucksville and Bessemer.

No regular quarrying and working has been done except at Pratt's Ferry, but much beautiful stone has been obtained at that point.

The Lower Carboniferous limestones are generally of a grayish color, sometimes oolitic, sometimes packed with fossils which make very pleasing variety in the color and shade in polishing.

The Tertiary limestones, especially the St. Stephens, while usually of open porous texture, hold ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white through shades of yellowish into red, and it would make a handsome decorative marble for inside work especially. This rock occurs along the banks both of the Tombigbee and the Alabama rivers, at Oven Bluff and St. Stephens, and some intermediate points on the former, and from Gainestown up to and above Marshall's Landing on the latter. It will probably soon be used in cement making and further acquaintance with its varieties, due to extensive working, will no doubt direct attention to those ledges of the formation which will make good marbles.

The dolomites of the Knox horizon are also in part of suitable quality for ornamental work. The geological map of the state will show the distribution of these rocks, which is very extensive. The spots where they have been actually cut and polished are few.

Lithographic Stone.

A bedded limestone of the Lower Carboniferous formation in Jackson county has been quarried on a very small scale, polished and engraved, and prints made therefrom, which are very satisfactory. One of these engraved stones is in the museum of the University.

Some of the dolomites of the Knox formation in the central parts of the state have also been pronounced to be fit for this purpose, but they have not been subjected to the practical test of actual use.

In the Report on the Valley Regions, Parts I and II, will be found other and fuller details concerning the calcareous rocks just described.

CHAPTER II.

CLAYS AND CEMENT.

The industries which in the near future bid fair to rival in importance that of Iron Making, are those connected with the utilization of our vast resources of clay and of cement materials, and these come appropriately next to be described.

KAOLINS, CLAYS AND SHALES.

Many accumulations of clay-like materials, are the insoluble residues left from the decomposition of other minerals and rocks, and when such clays have not been removed far from their parent rocks they are known as residual clays. Some of the purest of clays, *i. e.,* kaolins, are of this kind, resulting from the decomposition of feldspars, and on the other hand residual clays left after decomposition of limestones and of many crystalline rocks, are among the most impure of the clay kind.

Any of these residual clays, from the pure kaolins to the heterogenous mixtures left from limestones, etc., may, by the action of running water, be taken up and redeposited in secondary positions, becoming thus sedimentary clays. In this removal from one place to another, much of the contaminating material may be separated from the clayey matters, and in this way the secondary deposits may occasionally be freer from foreign admixtures than the original residual mass. But, as a rule, the opposite is the case, and the more a mass of clay has been subjected to transportation and redeposition, the more likely it is to take up and incorporate impurities of all sorts.

KAOLINS.

If we use this term to designate only the residual material from the decomposition of feldspars, the kaolins are in Ala-

bama restricted to the area of the crystalline or metamorphic rocks, embracing parts or all of Cleburne, Clay, Randolph, Lee, Macon, Tallapoosa, Elmore, Coosa, and Chilton counties. The kaolins are usually associated with veins of coarse grained granites or *pegmatites* intersecting the other rocks of this region, the kaolin being derived from the feldspars of these granites.

The northwestern part of Randolph and adjacent parts of Cleburne and Clay counties may be considered the central area of kaolin occurrence, though it is not wanting in the other parts of the region mentioned.

Up to the present time none of these deposits has been utilized in a commercial way, but from some of the Randolph county kaolin specimen sets of fine china ware were made and exhibited at the Art Institute Fair in Philadelphia, December, 1900, where they were awarded a premium.

Table 1—Composition of Kaolins.

	Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Total.
1	Washed Kaolin, 1½ m. N. E. of Milner, Randolph County	47.75	38.00	.20	*	*	*	14.85	100.80
2	Washed Kaolin, 1½ m. S. E. of Micaville, Cleburne County	45.20	38.00	*	.22	*	*	15.90	99.32
3	Kaolin, J. B. Ross, Miller Place, Micaville, Cleburne County	46.88	39.97	.08	.30	*	.64	13.87	101.74
4	Kaolin from S. ½ S. 28, Tp. 18, R. 11 E. Senator McIndoe, Randolph County	42.41	38.33	...	...	.70	...	17.42	......

*Trace.

CLAYS.

These include materials varying in composition from that of the vein kaolins above mentioned to the most impure aggregations having a clay basis.

China Clays.—The clays used in the manufacture of porcelain and fine white earthenware, which, from absence of iron burn white or nearly white at moderate temperatures, are called china clays. Their composition varies between somewhat wide limits, some having very nearly the composition of vein kaolins, while most of them contain a much higher percentage of silica. The china clays are associated with the older formations of the state in Calhoun, Talladega, Cherokee, DeKalb, Etowah, and perhaps other counties, and with the Tuscaloosa formation of the lower Cretaceous in Marion, Colbert, Fayette, Tuscaloosa, and Bibb.

The composition of the various qualities of china clays as yet examined in the state are shown in the appended table of analyses.

Table II—Showing Composition of China Clays.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Total.
1. China Clay, Eureka Mine, DeKalb Co..	47.00	38.75	.95	.70	*	*	12.94	100.38
2. J. J. Mitchell's Chalk Bluff, Marion county	47.20	37.76	*	*	*	*	14.24	99.20
3. Near Kymulga, Talladega county...	50.45	35.20	.80	.60	.62	....	12.40	100.07
4. F. Y. Anderson's, DeKalb county	53.50	34.45	.21	.30	*	.21	13.20	101.87
5. Rock Run, Cherokee county...	60.50	26.55	.30	.90	.65	2.70	7.20	99.50
6. Pegram, Colbert county	64.90	25.25	*	*	*	....	8.90	99.05
7. Briggs Frederick's, Chalk Bluff, Marion county	65.49	24.84	*	1.26	*	*	7.80	99.37
8. J. R. Hughes', Gadsden, Etowah county	67.95	20.15	1.00	1.00	*	1.87	8.00	99.97

*Trace.

Fire Clays.—These are clays which do not fuse when subjected to a high temperature, at least 2700 degrees Fahrenheit. Semi-refractory clays which cannot withstand a temperature of more than 2300 to 2400 degrees are sometimes called fire clays, and are in fact used along with other more refractory clays in the manufacture of certain classes of fire brick. The fire clays of non-plastic character are known as flint clays, and have nearly the composition of kaolinite. The only Alabama material which might be classed as a flint clay occurs very abundantly in the lower Claiborne or Buhrstone formation of the Tertiary. It is, however, a highly siliceous material carrying as much as 85 per cent. of silica, and containing a great number of the siliceous tests or shells of *radiolaria.*

The plastic fire clays are rather widely distributed, occurring in the Cambrian and Silurian formations, in the Lower Carboniferous, and most probably in the Coal Measures, though none has as yet been investigated from that horizon. The Lower Cretaceous or Tuscaloosa formation, which stretches as a belt around the southern and western edge of the older formations, is perhaps the most important in respect of its clays of all sorts. The following table will show the composition of refractory clays from a number of localities, together with their melting points. The bauxites of Cherokee county have been tested as to their refractory qualities and from these tests it appears that they may be advantageously used in connection with refractory fire clays in the making of fire brick. Several analyses and fire tests, of bauxites have been included in the table.

Manufactories of fire brick are located at Bessemer, Ashby, Brickyard, Fort Payne, etc.

Table III.—Composition of Refractory Clays.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Incipient Fusion, °Fah.	Vitrification, °Fah.
1. Rock Run, Cherokee County, Cambro-Silurian	47.60	36.70	1.10	1.30	*	*	14.20	3146°	.....
2. Fire Clay, Rock Run, Cherokee County, Cambro-Silurian	34.60	45.80	.52	.....	.....	.....	20.00	†3050°	.....
3. Low Grade Bauxite, Rock Run, Cherokee Co., Cambro-Silurian	31.20	44.28	1.45	1.00	.20	.....	22.60	3146°	.....
4. Low Grade Bauxite, Cambro-Silurian	18.30	54.39	1.36	.....	.....	.....	27.60	†3150°	.....
5. Fire Clay, Peaceburg, Calhoun County, Cambro-Silurian	51.90	35.00	.99	.23	.10	.55	11.30	2300°	3150°
6. Valley Head, DeKalb County, Lower Carboniferous	82.04	12.17	*	*	.33	.60	4.33	2400°	3050°
7. Fort Payne, DeKalb County, Lower Carboniferous	66.25	22.00	1.60	*	*	.75	9.05	2300°	3050°
8. Pearce's Mill, Marion County, Cretaceous	52.95	35.10	.80	*	*	.93	11.40	3050°	3150°
9. Bibbville, Bibb County, Cretaceous	74.25	17.25	1.19	.40	*	.52	6.30	2300°	3050°
10. M. & O. R. R. cut, W. of Tuscaloosa, Tuscaloosa Co., Cretaceous	58.13	24.68	3.85	.15	.32	1.78	11.78	2200°	3050°
11. Siliceous Flint Clay, Choctaw County, Tertiary	86.30	5.12	1.60	.46	.....	.....	6.60	2300°	2500°
12. Fire Clay, Cuba, Sumter County, Tertiary	50.25	35.20	1.80	.50	.30	.45	10.30	2102°	3038°‡

*Trace. †Not affected at this temperature. ‡Above.

Pottery or Stoneware Clays.—Stoneware clays are intermediate in their nature between fire clays and pipe clays, that is too impure for the one purpose and too good for the other. In the manufacture of stone ware it is essential that the clay should burn to a dense impervious body at not too high a temperature, and the color after burning should be uniform and good, if the ware is to be unglazed or is to be coated with a transparent glaze. Clays suitable for stone ware occur in the older formations, Cambrian, Silurian, Lower Carboniferous, and in the Lower Cretaceous or Tuscaloosa. This remark applies rather to the clays which have been investigated by the Geological Survey, and it should be understood that stoneware clays occur in other formations and in other parts of the state than those from which the subjoined examples have been taken.

In the table showing the composition we have given such notes as to color and character assumed in the burning, as will assist one in arriving at a correct estimate of the properties of the clays.

Table IV—Composition of Stoneware Clays.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Remarks.
1. Stoneware Clay, Blount Co., F. S. White	61.50	26.20	2.10	0.50	0.43	0.70	7.29	At 2200° Fah. burns to dense body—cream color. At 2350° vitrifies—light gray color.
2. Pottery clay, Rock Run, Cherokee Co. C. C. Davenport	57.00	17.80	5.60	2.10	1.20	6.00	9.45	At 2150° Fah. fuses to transparent glass, suitable for natural glaze.
3. Pottery clay, McLean's, Elmore County	62.60	29.98	.72	.40	.36	.65	8.60	Burns to dense, smooth, bluish white body. Vitrifies at 2150° Fah. Viscosity at 2400° Fah.
4. Pottery clay, Tuscaloosa Co., H. H. Cribbs	65.35	21.30	2.72	.60	.86	*	8.79	Burns to dense yellowish body. Vitrifies at 2200° Fah. Viscosity at 2400° Fah.
5. Pottery clay, Pegram, Colbert County, J. W. Williams	66.45	18.53	2.40	1.50	1.25	*	8.68	Burns to dense yellowish white body. Vitrifies at 2300° Fah. Viscosity at 2500° Fah.
6. Pottery clay (refractory) Fayette Co. Shirley's Mill	72.20	17.42	2.40	*	*	.56	7.52	Burns to yellowish white body. Vitrifies at 2200° Fah. Viscosity at 2400° Fah.
7. Pottery clay, Franklin Co., Thos. Rollins	67.50	19.84	6.15	.12	.10	....	7.65	Burns to reddish gray body. Vitrifies at 2100°. Viscosity at 2300° Fah.
8. Pottery clay, Marion Co. 10 m. S. W. of Hamilton	70.00	21.31	2.88	.20	*	*	6.85	Burns to grayish buff color. Vitrifies at 2150° Fah. Viscosity at 2350° Fah.
9. Stoneware clay, Fayette Co., H. Wiggins	63.27	19.68	3.52	1.30	*	1.20	9.80	Burns to dense red body. Vitrifies at 2100° Fah. Viscosity at 2300°.
10. Stoneware clay, Lamar Co., Fernbank	69.50	13.00	6.40	.25	*	*	10.10	Burns to hard dense body of deep red color. Vitrification at 2100° Fah. Viscosity at 2300°.
11. Stoneware clay, Pickens Co., Roberts' Mill	68.23	20.35	3.20	.34	*	.74	7.16	Burns to dense buff body. Vitrification at 2200° Fah. Viscosity at 2400°.
12. Pottery clay, Cuba, Sumter County	50.25	35.20	1.80	.50	.30	.45	10.30	Burns to whitish color, becoming buff at 2354° Fah. Not vitrified at 3038°.

*Trace.

Of the above analyses, Numbers 1 and 2 are from Paleozoic formations; Numbers 3 to 11, inclusive, are from the Lower Cretaceous, (Tuscaloosa), and 12 is from the Tertiary, and they have been selected from a great number to illustrate the wide distribution of clays of economic value.

Clays and Shales for Portland Cement Making.—Under the head of Cement Resources, we have given a number of analyses of clays adapted to use in cement making, and add here several others.

These clays, like the preceding, are widely distributed, as may be seen from the localities given, and they are from a great variety of geological formations.

Analyses of a few shales from the Coal Measures are also appended as being very likely to come into use in this connection, not only because of the fitness of the chemical composition, but also on account of their proximity to the Trenton and Lower Carboniferous limestones and to the mines of coal.

While the composition of the limestone which is to be used in the cement manufacture, varies in the different formations, and will in a measure determine the character of the clay which will be suitable to mix with it, yet there are certain limits within which the composition of the clay must fall in order to adapt it to the rotary kiln in the burning of the cement. Ordinarily a clay will give good results which contains as nearly as possible 60 per cent. of silica and about one-third as much, or less, of alumina and iron oxides, the smaller the proportion of iron the better. The clay should not contain more than 2 per cent. of magnesia and as little sulphur as may be. (D. Fall.)

Table V.—Composition of Shales and Clays suitable for Portland Cement making.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Sulphur Trioxide.	Alkalies.	Ignition.
1. Carboniferous Shale, Coaldale, Jefferson Co.	57.22	24.72	7.14	0.49	1.88	0.40	....	7.09
2. Carboniferous Shale, gray, Birmingham, Jefferson County	57.80	25.00	4.00	2.10	.80	....	1.80	7.50
3. Carboniferous Shale, yellow, same locality as No. 2..............	61.55	20.25	7.23	*	.99	....	2.25	6.19
4. Hull's Station, A. G. S. R. R., Tuscaloosa Co., Cretaceous...........	61.25	25.60	2.10	.25	.82	....	1.35	8.10
5. M. & O. R. R., 10 m. West of Tuscaloosa, Tuscaloosa County. Cretaceous	58.13	24.68	3.85	.15	.32	....	1.78	11.78
6. Blount County, F. S. White, Paleozic	61.50	26.20	2.10	.50	.43	....	.70	7.29
7. Chalk Bluff, Elmore Co., Cretaceous	60.38	20.21	6.16	.09	.72	....	1.80	10.21
8. Cribb's place, Bedford, Lamar Co., Cretaceous	60.90	18.98	7.68	*	*	....	*	13.36
9. Sand Mountain Cut, M. & O. R. R., Bibb Co., Cretaceous.......	58.50	24.95	4.65	.50	.30	....	.20	.....
10. Same locality as 9...	59.33	25.28	3.37	.80	.10	....	.65	9.50
11. Blue Cut, M. & O. R. R., 10 m. W. of Tuscaloosa. Cretaceous...	62.70	22.80	1.95	.90	.10	....	.70	10.00
12. Reform, M. & O. R.R. Pickens Co., Cretaceous	62.55	24.62	2.40	.30	.20	....	.42	10.00
13. Bluff at steamboat landing, Lower Peach Tree, Wilcox Co. Tertiary	62.10	15.14	3.20	4.90	1.60	....	2.75	9.65

*Trace.

Shales and Clays, suitable for Paving Brick, Pressed Brick, etc.—The Carboniferous shales at Coaldale, and at the Graves Mines near Birmingham, analyses of which have been given in the preceding table, have for a number of years been used in the manufacture of vitrified brick for paving, and have come extensively into the market. In the various clay deposits mentioned above there are clays in abundance, which have been used in making all the finer grades of building bricks.

It seems superfluous to speak of these in more detail, since they and the other kinds of clays are somewhat fully described in Bulletin No. 6, of the Alabama Geological Survey, prepared by Dr. H. Ries, of Cornell University.

THE CEMENT RESOURCES OF ALABAMA.

SLAG CEMENT.

No details are here given concerning the slag cement materials, since they are manufactured products. Attention is directed, however, to the circumstance that our furnaces are daily turning out vast quantities of slag suitable for making cement, and that plants for this purpose are already in active and successful operation.

PORTLAND CEMENT.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted for Portland Cement manufacture, and widely distributed throughout the state. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location will be immensely increased when work is begun on the Isthmian canal, for cement plants located in Alabama will be more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the state lie so close to each other and above all, so close to the great coal mines which must supply the fuel, that the establishment of

Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our state beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent. lime carbonate and 25 per cent. of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance. In the present statement, therefore, the Alabama localities where cement industries may be developed will be discussed under four headings, according to the limestone available in each locality.

Disregarding limestone formations whose chemical composition renders them unsuitable for use in the manufacture of Portland cement, as well as those whose outcrops are small or badly located with regard to transportation routes, the limestones of four formations may be considered as particularly well adapted for use in cement manufacture. These are:

(1) Trenton limestone (Silurian) of Northern Alabama.

(2) Bangor limestone, (Lower Carboniferous), of Northern Alabama.

(3) Selma chalk (Cretaceous), of Middle Alabama.

(4) St. Stephens limestone, (Tertiary), of Southern Alabama.

1. *Trenton Limestone.*

Areal Distribution.—The Trenton limestone occurs in all the northeast and southwest trending valleys of Northern Alabama, outcropping usually in a narrow belt near the base of the Red Mountain ore ridges, though sometimes occurring high up on the flanks of these mountains, and in some localities underlying considerable areas of lowlands in the valleys, as at Pelham, Siluria, Longview, Calera, Shelby, Rock Springs, etc.

Chemical Composition.—As this rock is extensively quarried for lime burning and for furnace flux, many analyses are avail-

able from which it may be seen that it is a rather pure limestone, carrying normally from 1 to 5 per cent. of silica, and from .5 to 1 per cent. of iron and alumina oxides, and from 90 to 93 per cent. of carbonate of lime, with carbonate of magnesia varying from .75 to 3 per cent. It is hence a pure limestone, requiring an addition of one-fourth to one-third of its weight of clay or shale to make a suitable cement mixture.

Table I.—Average Composition of Trenton Limestones.

Locality.	Insoluble silica.	Iron and alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulphuric acid.
1. Rock Springs Quarry, Etowah Co.	1.00	.30	97.00	*	*
2. Gate City Quarry, Jefferson Co. Average of five analyses	3.78	1.90	91.69	....	....
3. Longview Quarries, Shelby County. Average of three analyses	.44	.16	98.63	.92	....
4. Shelby Quarry, Shelby County. Average of three analyses	1.81	.77	96.03	1.67	....
5. Vance Quarry, Tuscaloosa County. Average of car load lots	4.68	1.22	88.85	3.52	....
6. Calcis Quarry, Shelby County. Average of six analyses	.51	.42	96.72	1.84	....

*Trace.

Physical Character.—It is a compact blue limestone of normal hardness, and would therefore require more power to crush and pulverize it than the softer rocks of the Selma Chalk and St. Stephens limestone, but it is practically free from combined water, and its use would entail no loss of heat in volatilizing moisture.

Accessibility to Clay or Shale.—In all localities of the occurrence of Trenton limestone, the shales of the Coal Measures are in close proximity, and, so far as these have been analyzed, of suitable composition for mixing with the limestone in cement making. The shales from the Graves Mines below noticed, are near the Gate City quarries, and those of the Cedar Grove mines in Tuscaloosa county are close to the limestone quarries at Vance. In both localities the shales are at coal mines in active operation.

Table II—Composition of Shales and Clays near Trenton Limestones.

Locality.	Silica.	Alumina.	Ferric oxide.	Lime.	Magnesia.	Sulph. anhydride.	Alkalies.
1. Graves Coal Mine, Jefferson Co. Gray shale	57.80	25.00	4.00	2.10	.80	....	1.80
2. Graves Coal Mine. Yellow shales	61.55	20.25	7.23	*	.98	....	2.25
3. Cedar Cove Coal Mines, Tuscaloosa Co. Shale above coal seam	58.50	16.17	11.33	1.22	1.17	.77	....
4. Woodstock, Bibb Co. Cretaceous clay	65.82	24.58	1.25	....	....	....	....

*Trace.

2. *Bangor Limestone.*

Areal Distribution.—The Bangor limestone of the Lower Carboniferous, is extensively developed in Northern Alabama, being well exposed along most of the railroads radiating from Birmingham. It is in fact so widely distributed that a detailed geological map would be required to give any adequate idea of the location of its various outcrops.

Chemical Composition.—In the vicinity of Birmingham ,at Blount Springs, at Bangor, at and near Trussville, this limestone has been extensively used as a flux in the furnaces. In consequence, numerous analyses are available, and very close estimates can be made both of its normal composition and of probable deviations from the normal. These analyses show that the Bangor limestone will usually carry 92 to 98 per cent. lime carbonate; 1 to 5 per cent. of silica; and 1 to 2 per cent. alumina and iron. Normally it does not contain over 1½ per cent. magnesium carbonate, though one exceptional analysis shows a little over 8 per cent. of that constituent.

It may, therefore, be considered as a very pure limestone, and available for use in Portland cement making; requiring the addition of one-fourth to one-third of its weight of clay or shale.

Table III.—Composition of Lower Carboniferous (Bangor) Limestone.

Locality.	Silica.	Iron and alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulphur.
1. Fossick's Quarry, Rockwood, Ala. Average sample	.50	1.45	96.58	2.58	....
2. Blount Springs Quarry. Average five analyses. J. R. Harris	.95	1.01	96.25	1.27	.03
3. Vann's Quarry, near Trusville. Average of six analyses. J. R. Harris......	.81	.63	07.05	1.00	.02
4. Worthington Quarry, near Trussville. Av'ge. of 2 analyses by C. A. Meissner	2.64	2.31	87.51	4.20	....
5. Compton Quarry, Murphree's Valley. Stock house sample. Dr. W. B. Phillips	2.80	.70	94.59	....	....

Physical Character.—The Bangor limestone is a limestone of normal hardness, and cannot therefore be quarried so readily and so cheaply as the Cretaceous and Eocene limestones to be discussed later. Limestones resembling the Bangor in hardness are successfully utilized in Portland cement manufacture in New York, Ohio, Indiana, Missouri, and other states; so that this character alone need not be considered as rendering it unavailable. Its hardness is, moreover, largely counterbalanced by the fact that as quarried it will be practically free from water, and will, therefore, require the expenditure of little coal for complete drying.

Accessibility to Clay or Shale.—Thick deposits of shale of Coal Measures occur near the outcrops of the Bangor limestone in the vicinity of Birmingham. In some parts of the valley to the northeast of Birmingham excellent beds of clay at the base of the Lower Carboniferous formation, are quite extensively developed. Both the overlying shales and the underlying clays have been worked to some extent in this region, the product being used in brick and pottery manufacture. Examination of a series of analyses of these shales and clays as well as of some clays belonging to the Cretaceous formation and occurring in close proximity to some of the limestone quarries in the Tennessee Valley, shows that all of these deposits could fur-

Plate V.—Bluff of Selma Chalk, left bank of Tombigbee River, Demopolis.

nish material suitable for admixture with the limestone, the underlying clays being apparently slightly better in composition than those of the shales of the Coal Measures above the limestone. The Cretaceous clays appear to be entirely suitable.

Table IV.—Composition of Clays and Shales near Lower Carboniferous Limestone.

Locality.	Silica.	Alumina.	Ferric oxide.	Lime.	Magnesia.	Sulph. anhydride.
1. Ft. Payne, DeKalb Co. Lower Carboniferous clay	66.25	22.90	1.60	....	....	....
2. Colbert Co., Pegram. Cretaceous clay	66.45	18.53	2.40	1.50	1.25	....
3. Colbert Co., Pegram. Cretaceous clay	64.90	25.25	*	*	*	....

*Trace.

The shales and clay in Table II above are also available for the Bangor limestone.

3. *The Selma Chalk (Cretaceous), of Middle Alabama.*

Areal Distribution.—The Selma Chalk or "Rotten Limestone" outcrops as an east and west trending belt, Eutaw, Selma and Montgomery, being near its northern, and Livingston, Linden, Union Springs, near its southern border. In its widest portion, towards the western part of the state, this belt is about 25 miles from north to south, but it thins to the eastward, disappearing entirely some 15 miles west of Columbus, Ga. The belt is intersected by the Alabama, Tuscaloosa, and Tombigbee rivers, and a characteristic bluff of this rock is shown in Plate V, a view of the left bank of the Tombigbee River at Demopolis.

Chemical Composition.—The Selma Chalk is about 1,000 feet in thickness, and is in general terms a very argillaceous, chalky limestone, varying considerably in the proportion of clayey matters in its different parts. In the upper and lower thirds of the formation, the proportion of clay is high and carbonate of lime will not usually exceed 60 or 65 per cent.

The rock of the middle third of the formation, which is the part best suited for cement making, will average about 70 to 85

per cent. of carbonate of lime, and 30 to 35 per cent. of silica. alumina and iron. Its magnesia content is low, well within the requirements for a Portland cement material.

The limestone in some localities shows a considerable amount of iron pyrites, however, which will cause the resulting cement to carry a relatively high percentage of sulphates.

The highly argillaceous character of the Selma Chalk has the advantage that but little additional clay will be required to make a perfect Portland cement mixture.

In the table below, in addition to the analyses of rock containing from 75 per cent. upwards of carbonate of lime, others have been added of rock carrying less than 75 per cent. of this ingredient, and which by proper mixture with the higher grades of rock might make a cement mixture without the addition of any clay.

Table V.—Composition of Selma Chalk.

Locality.	Insoluble matters.	Iron and alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulph. anhydride.
1. Roberts' place, near Gainesville, Sumter County	19.10	3.70	75.57	1.24	.69
2. Jones' Bluff, Tombigbee River, at Epes, Sumter County	9.44	1.76	86.28	1.02	....
3. Bluffport, on Tombigbee River, Sumter County	11.68	1.82	85.10	1.25	....
4. McDowell's Bluff, Tombigbee River, Sumter County	6.06	1.62	90.40	1.15	....
5. Material used in Alabama Portland Cement works near Demopolis, Marengo County	12.50	2.76	80.71	1.05	1.62
6. Van Dorn Station, east of Demopolis, Marengo County	14.36	2.80	80.47	1.30	....
7. Uniontown, Perry Co., Pitt's place....	16.18	3.08	75.35	1.35	....
8. One mile S. of Uniontown, Perry Co.	12.14	2.60	83.65	1.53	....
9. R. R. cut, Milhous Station, So. R'y. Dallas County	15.30	2.44	80.10	.98	....
10. Bluff at Gainesville, Sumter Co.....	18.42	10.79	65.21	1.57	.30
11. Hatch's Bluff, Tuscaloosa River, above Demopolis. Hale County......	41.18	4.16	44.78	2.68	....
12. Selma, Dallas County. Boat landing, Alabama River	16.16	11.22	65.08	2.42	1.40
13. O. M. Cawthon, near Selma, Dallas County	28.40	3.68	64.10	2.58	.08
14. Cahaba, Dallas Co., Alabama River..	31.04	2.94	64.37	.79	....

Physical Character.—The Selma Chalk is soft, and may therefore be easily and cheaply quarried and pulverized. In this respect it is probably the most satisfactory cement material in the United States. Enough should be quarried in dry weather, however, to carry the plant entirely through rainy seasons, for the chalk takes up water easily, and the expense of removing this absorbed water would be considerable.

Accessibility to Clay.—Clay beds are adajcent to, and in some cases immediately overlying, the Selma chalk. These clays, which are probably residual in origin, are in general very suitable for use, in connection with the limestone, in making up the cement mixture. It seems probable that in no case will a plant, located on the Selma chalk, have to go more than a few hundred yards to obtain the necessary supply of clay.

Table VI.—Composition of Clays near Selma Chalk.

	Silica.	Iron and alumina.	Calcium oxide.	Magnesia oxide.	Sulphuric anhydride.
1. Residual clay over chalk rock, Demopolis, Marengo County. Used in cement works	55.64	26.25	.91	1.97	*
2. Residual clay over chalk rock, Uniontown, Perry County. Pitts place	69.57	19.04	.37	....	....
3. Residual clay over chalk rock, Uniontown, Perry County. Morgan place..	56.74	27.90	.70	1.27	.13
4. Clay on Read place, White Bluff, Dallas County, on Alabama River	56.90	27.71	.86	1.64	.09

*Trace.

Besides the residual clays above noted, and which are nearly everywhere available over the chalk, it seems entirely practicable to use mixtures in varying proportions of the purer forms of the chalk as shown in analyses of Table V, Nos. 1 to 9, with more argillaceous varieties such as those shown by analyses 10 to 14. In this way a proper cement mixture might be obtained without the use of clays, where they were difficult to obtain.

4. *The St. Stephens Limestone (Eocene), of Southern Alabama.*

Areal Distribution.—The St. Stephens limestone outcrops in a belt 10 to 15 miles wide (from north to south) in Southern Alabama. The counties of Geneva, Covington, Conecuh, Escambia, Monroe, Clarke, Washington, and Choctaw are in part within this belt.

The high bluff at St. Stephens on the Tombigbee River shown in Plate VI, illustrates well the general characters of the outcrops of this rock along the banks of the Tombigbee and Alabama Rivers.

Chemical Composition.—Most of the St. Stephens beds are slightly argillaceous limestones, less clayey than the Selma chalk; while occasional beds of pure limestone occur. Both types could be utilized in Portland cement manufacture; the purer limestones requiring the addition of more clay than would the argillaceous beds.

Table VII.—Composition of the St. Stephens Limestone.

Locality.	Insoluble matters.	Iron and alumina oxides.	Carbonate of lime.	Carbonate of magnesia.	Sulphuric anhydride.
1. Bluff at St. Stephens, Washington Co.	3.38	1.04	92.85	1.92	.13
2. Oven Bluff, Tombigbee R., Clarke Co.	6.06	1.38	89.32	2.28	.15
3. Marshall's landing, Alabama River, Monroe County	2.82	1.20	94.07	1.90	.08
4. Taliaferro's Heights, near Evergreen, Conecuh County on Murder Creek	4.04	.96	91.31	1.83	.07
5. Near Evergreen, Conecuh County	1.26	1.72	96.09	.65	.02
6. Near Evergreen, Conecuh County	2.75	2.73	93.31	.23	.02

Physical Character.—In physical character the St. Stephens limestone varies from a soft chalky material, like the Selma chalk, to a rather hard limestone which in some localities takes a good polish and makes a very fair quality of marble. The softer beds could be quarried and crushed as readily as could

Plate VI.—St. Stephens Bluff, Tombigbee River.

the Selma chalk; even the harder beds will not be so expensive to handle as the Bangor or Trenton limestones of Northern Alabama, or as many limestones now worked for Portland cement in the Northern states.

Accessibility to Clay.—Residual clays from the decomposition of the St. Stephens limestone are usually present over most of the beds of this rock. These clays are in general quite similar to the residual clays of the Selma chalk, as may be seen by the appended analyses.

But in most of its territory, the St. Stephens limestone is mantled by the strata of the Grand Gulf formation, which includes beds of clay of considerable thickness and extent, and of quality adapted to the purposes of cement manufacture. The analyses of some of these clays will show their chemical character. The samples taken for analysis are from beds that occur in the immediate vicinity of the limestone outcrops, and either on navigable river or railroad line.

Table VIII.—Composition of Clays near St. Stephens Limestone.

Locality.	Insoluble matters.	Iron and alumina oxides.	Carbonate of lime.	Carbonate of magnesia.	Sulphuric anhydride.
1. St. Stephens Bluff, Tombigbee River, Washington County. Residual clay over limestone	59.71	24.79	.48	....	....
2. Marshall's Landing, Alabama River, Monroe County. Residual clay over limestone	51.30	35.22	1.37	.96	.41
3. Clay of Grand Gulf Formation, Manistee Juncn., L. & N. R. R., Monroe Co.	66.60	25.86	.34	.34	.89
4. Grand Gulf clay, St. Stephens, Washington County	60.68	25.60	.48	.38	*

*Trace.

The Fuel.—The question of a cheap fuel will be an important one for the limestones of the Coastal Plain and while these rocks occur along the banks of the Tombigbee and Alabama Rivers or on railroad lines, yet the high rates of freight make it difficult to get the coal from the fields of Northern Alabama at a

price that would insure the success of a plant. This in time will correct itself, but meanwhile the beds of lignite, which are numerous and of sufficient thickness at many points contiguous to the limestone outcrops and to the navigable streams, are well worth careful testing as to their suitability for use in this manufacture. It seems probable that gas might be made from them which would replace the high grade coals, and thus start up a new industry in this section of the state.

Those interested in this subject are referred to a special Bulletin on the Cement Resources of Alabama, published by the Geological Survey, and to a chapter on the same subject published by the United States Geological Survey, in Bulletin No. 225.

NOTE.—In the preparation of this account of the Cement Resources, the writer has had many valuable notes and suggestions from Mr. Edwin C. Eckel, of the United States Geological Survey.

CHAPTER III.

MISCELLANEOUS.

In this chapter will be considered those minerals upon which minor industries are based, or which give promise of being capable of being turned to profitable account.

Gold.

The gold ores of Alabama occur in the northwestern three-fourths of the region of the Metamorphic and Igneous Rocks, mainly in Cleburne, Clay, Talladega, Coosa, Chilton, Elmore, Tallapoosa, and Randolph counties. The area included is something like 3,500 square miles. The gold deposits are not uniformly distributed through this territory, but occur in several roughly parallel belts having a general northeast southwest direction. The ore bodies in Alabama as elsewhere, are quartz veins of the bedded or segregation type, occurring usually in feebly crystalline or semi-crystalline schists, often wrongly called talcose schists, though the term *talcoid* might profitably be used in describing them. Dikes of igneous rocks, granites, and diorites especially, are very commonly observed in the immediate vicinity of the gold veins. The quartz veins are sometimes of lens shape, and of considerable size, sometimes not thicker than the hand, and are apt to be in clusters or groups, the members of which are separated by barren rocks.

At times the quartz veins are associated with mica schists and other well crystallized rocks and occasionally the slates themselves in the immediate vicinity of the veins are gold bearing. Such slates hold often a great number of small quartz lenses the fillings of small fissures or parting in the slate, due generally to movements caused by the intrusion of igneous rocks. In many places the slates with numerous small quartz veins are highly graphitic, and in one locality at least, in Clay county, the gold bearing graphitic slate contains well defined

and determinable Carboniferous fossils (*lepidostrobus.*)

The gold ores run in value from a mere trace of gold to $500 a ton, but the richest ores are thin. Where the ore body consists of thin lenses in gold bearing slates the values seldom run higher than $2.00 a ton.

Above the water level these ores are all free milling, porous, friable and usually iron stained, at times showing free gold to the eye.

Below water level are the sulphurets in Alabama as elsewhere.

The quartz veins vary in thickness from a few inches to 50 feet, while the ore bodies consisting of thin lenses imbedded in the impregnated slates are sometimes several hundred feet thick. All these ore bodies maintain their values with the depth so far as they have been worked.

In addition to the above, there are a few placer deposits of much importance, and decayed rock, *saprolite*, from which gold may be obtained by merely washing.

Perhaps the most prominent and persistent of the ore leads is that known as the Devil's Back Bone, crossing Tallapoosa county near its northwestern border. In this the quartz veins are from 6 to 50 feet in thickness, and in the immediate vicinity of this ridge are several large ore bodies consisting of quartz lenses in impregnated highly graphitic slates without any well defined wall. The Back Bone is the most southeasterly of the gold belts and is probably the richest.

Only one of the belts of fully crystalline rocks, viz., the most northwesterly, carries any gold deposits of consequence, so far as is yet known.

Mining operations of greater or less magnitude have been conducted in more than 100 localities in the following counties: Tallapoosa, Cleburne, Randolph, Clay, Talladega, Coosa, Chilton, and Elmore.

In Tallapoosa county there are over 30 of these mines, the most important being in the Silver Hill, Goldville, Hog Mountain, and Eagle Creek districts.

Cleburne county has nearly thirty gold mines, the most important being in the Arbacoochee, Chulafinnee, Kemp's Creek, Turkey Heaven, and Kemp Mountain districts.

In Randolph county there are more than 20, mainly in the Goldberg, Pinetucky, and Wedowee districts. Clay county has half a dozen, all in the Idaho district. Talladega has several in

the vicinity of Waldo. Coosa has several in the vicinity of Rockford, and about Parson's Mines. In Chilton county the mining has been done on Blue Creek and Rock Creek, and in Elmore only on Peru Branch.

To the series of semi-crystalline slates, which are demonstrably metamorphosed sediments, we have in Alabama given the name of Talladega slates, and they correspond in appearance and geographical position to the Ocoee of Dr. Safford in Tennessee. These have very generally been deemed older than the Cambrian, notwithstanding strong suspicion, lacking convincing evidence, that they were metamorphosed Paleozoic strata. The finding of Carboniferous fossils in one of these belts, eight or ten miles from its western border, has made it certain that some of the so-called Talladega slates are of Paleozoic age, and probable that all of them are.

More than two-thirds of the gold workings of the state are in the Talladega slates, of which there are four separate belts of unequal width, the two being farthest to the northwest being the largest, and perhaps least important. They run together near the Georgia line. The other two belts are narrower and shorter, but at the same time more important. They are the Silver Hill and Goldville belts. To the former belong the Silver Hill, Mass, Garrett, Long Branch, Blue Hill, Farrar, Gregory Hill, Nicholls, Gold Hill, Bonner-Terrell, Eagle Creek, and other mines less well known.

The Goldville belt carries the numerous mines about Goldville, Goldberg, Hog Mountain, and Turkey Heaven, and those about Wedowee.

The Talladega or Terrapin Mountain belt carries the Parsons and Kemp Creek mines near the eastern border and the Riddle's Mill, Story, Woodward, and other mines near the western border. The mines and placers of Arbacoochee and Chulafinnee are also near the southeastern edge of this belt. Most of the mines alluded to above are mere surface diggings and shallow shafts, many of them put down prior to the great California gold excitement in 1849. The placers of Arbacoochee and Chulafinnee, and Long Branch are the most important, and work has been going on in them continuously for the past 60 years, since they always yield some returns for the labor expended on them. Very fair nuggets are obtained from Arbacoochee every year, by sluicing and panning.

Mining on the quartz veins has been carried on in a very unscientific way, and hardly ever beyond the water level. Until the past year or two no plant has been in operation for working the sulphurets. One establishment of the kind using the cyanide process is at Hog Mountain, and is meeting with success.

Most of the early mining of quartz veins was done years ago in the Goldville district and a line of old pits and shafts may still be seen along a distance of 12 miles or more. Extensive workings were also in the old time carried on about Silver Hill. Pinetucky also was one of the early mines, and it has been in continuous operation to the present time. The Pinetucky shaft is about 100 feet deep.

Gold mining in Alabama has not been as yet one of the paying industries, a fact due as we believe mainly to the insufficient capital and inadequate methods and appliances in use. The experiment at Hog Mountain will, therefore, be watched with interest.

Recently at Kemp Creek postoffice, in Cleburne county, extensive preparations have been made for the hydraulic working on a large scale of some very promising placer deposits. Water is brought a distance of four miles by ditch and flume, and the successful outcome of this enterprise will no doubt lead to the establishment of similar plants in other places.

In conclusion, we may say that the gold fields of Alabama offer inducements to capitalists, since there are very extensive deposits of ore, low grade, it is true, but of such extent and so easily and cheaply mined and milled, that there seems to be little doubt of the result if the working be done on sufficiently large scale and with the most improved methods and those best adapted to the character of the ores.

In Bulletins 3 and 5 of the Geological Survey will be found more detailed information regarding the gold region, and the material is now nearly all in hand for a final report on the subject.

Copper Ore and Pyrite.

Pyrite.—Along the eastern base of the range of mountains known as the Talladega Mountain, there is a belt of greenish rock, resulting from the alteration of an igenous rock, and to this we have given the name Hillabee Schist. Its outcrops have

been followed from Chilton county west of the Coosa river, northeastward through Coosa, Clay, and Cleburne counties to the Georgia state line. At intervals along this entire distance there are occurrences of pyrite in the form of crystals disseminated throug the mass of rock; and in beds more or less compact of crystalline pyrite. From near Dean postoffice, in Clay county, northeastward for several miles, the bed of pyrite appears at its best, being several feet in thickness and quite free from impurities.

This bed was first worked for copper, of which it holds a small percentage, and at the Old Montgomery Copper Works, there was considerable activity during the war between the states in manufacturing blue stone and perhaps other copper salts. The remains of the furnaces and other buildings are still to be seen.

Recently the Alabama Pyrites Company has begun work on this vein which averages six feet in thickness, and extends along the outcrop about one and a half miles. The analyses show an average of 42 per cent. of sulphur.

At present the workings go down about 450 feet, and the daily capacity is 150 tons. A railroad has been completed from Talladega to Pyriton, the station at the mines.

In the southeastern part of Clay county near Hatchet Creek postoffice, and at the old McGhee copper mines, there are other occurrences of the pyrite, and at the first named locality considerable work has been done in raising and shipping pyrite. These localities are not yet on a railroad line, and the hauling of the pyrites in a wagon over the mountain can hardly be done without loss.

Copper Ore.—As has been intimated above, the pyrite of the Hillabee Schist contains a small percentage of copper as a rule, but the amount seems hardly to be great enough to make it a copper ore. Near the southern border of Cleburne county at Stone Hill is the copper mine known originally as Wood's copper mine. A mile or two northeast of this there is another mine known as the Smith copper mine. The discovery of copper here was made about 1870, and a great deal of work was done during 1874-5 and 6. The main body of the ore consists of chalco-pyrrhotite and chalco-pyrite, along with a good deal of pyrite containing very little copper.

As is the case elsewhere, the first mining here was in the rich decomposition products of the weathered parts of the vein and

for several years these ores were hauled in wagons to Carrollton, Ga., and shipped thence to Baltimore for smelting. With the partial exhaustion of these surface ores smelters were erected at the mines, and from 1876 to 1879 the shipments from the mine were in the shape of ingots of copper. From 1879 to 1896 work was suspended; but in the last named year a new company was organized, "The Copper Hill Mining Company," the old mines were pumped out, a new house was erected over the slope, new machinery put in, and the mining was resumed, and a large amount of ore was brought out and stored around the opening, where most of it still remains, for no smelters were erected, and for want of railroad facilities the ore could not be profitably shipped. The new workings showed the ore body at a depth of 80 feet and below to be some 24 feet thick between walls of igneous rock of the general nature of diorite. Analyses show that the ore is richest near the two walls and that some ten feet of the ore will average 7 per cent. of copper, while the entire ore body will average probably 3 per cent.

Comparatively little mining has been carried on at the Smith mine.

Graphite.

This substance is very generally distributed among the metamorphic or crystalline rocks, and it occurs in two modes. In the feebly crystalline schists or slates which we have called the Talladega, and which in part, at least are paleozoic sediments, of as late age as the Coal Measures, the graphite is very often found as a sort of black graphitic clay free from grit and is frequently used as a lubricant. In this condition the graphite is very difficult to separate from the other matters with which it is mixed. Examples of this mode of occurrence are to be seen near Millerville, in Clay county, and about Blue Hill and Gregory Hill, in Tallapoosa.

In the mica schists and other fully crystalline rocks of this region the graphite is present in the form of thin flakes, or *lamellae*, and is comparatively easy to separate from the enclosing rock. This variety of graphite has been worked at several points in Clay, Coosa, and Chilton counties.

Some of the graphitic schists hold as much as 20 per cent. of graphite, but the average content is less. The belt of graphitic

rocks extends from Chilton county northeastward into Georgia.

In Tallapoosa county a mile below Tallassee there is a third mode of occurrence, or perhaps a modification of the second above described. Here a belt of garnetiferous schist crosses the river in an outcrop of about 100 yards width. In this schist the graphite is found in lenses or flakes which sometimes attain a diameter of two inches. As the rock disintegrates the graphite lenses weather out and are scattered loose over the surface. The same belt or a similar one is to be seen where it crosses Wolf Creek in the northern portion of Macon county.

Mica.

While mica has not been sent from Alabama to the market in anything more than experimental way, yet there is much reason for thinking that a good merchantable article can be obtained at a number of points in Chilton, Coosa, Clay, and Randolph counties. In a belt of mica schists extending through these counties, there are frequent veins of a coarse grained granite or *pegmatite,* in which the constituent minerals, quartz, feldspar, and mica, are segregated in large masses. The feldspar is very generally weathered into kaolin, and it is from these occurrences that we get all the true or vein kaolin. The mica in its turn is present in the form generally of large rough masses or boulders, from which it may be split out in sheets of varying size. In all this belt there are ancient pits or mines in which trees are now growing with diameter of 18 inches.

Around the mouths of these old diggings are great piles of broken-up refuse mica, apparently showing that a large amount of the mineral had been taken from them. In North Carolina, and probably elsewhere, the old mines of this kind have often proven to be the best places for obtaining good mica in modern times, and this fact may serve as a hint to those who contemplate mica mining in this state.

Most work in getting mica has probably been done near Micaville, in Cleburne county, and at the Pinetucky mine, in Randolph. Many tons of mica, some of it in large sheets six to ten inches in size, have been gotten up and stored away in a house, which was destroyed by fire and the mica injured, so that it was never sent to market. None of the localities is near

a railroad. A little testing, it can hardly be called mining, has also been done in several places in Clay county, and also in Coosa and Chilton.

Corundum, Asbestos and Soapstone.

These minerals are very commonly associated together and with dikes of basic igneous rocks. The main *corundum* localities are in Tallapoosa county, near Easton postoffice, two or three miles northwest of Dudleyville; and near the river, several miles south of Alexander City. In Coosa county many fine crystals have been obtained from the vicinity of Hanover. While the neighboring rocks in all these localities are *peridotites,* the masses of corundum are mostly found loose in the soil. Very little has been done at any of the localities mentioned towards actual mining, though a fiew shallow pits have been sunk, in some of which the corundum was obtained in small quantity. Dr. Lucas some years ago collected and shipped from Tallapoosa county such fragments and masses of corundum as were to be obtained from surface occurrences and shallow pits.

Asbestos is not uncommon in all the regions which show corundum, but it has not yet been found in quantity or of quality which would make it of commercial value.

Soapstone appears to be much more widely distributed than the other two associated minerals, and it is found in nearly if not all the counties of the metamorphic region. One common occurrence of it in Tallapoosa, Chambers, and Randolph counties particularly, is as a greenish schistose rock, consisting of a felt or mesh of actinolite crystals and soapstone, evidently the result of the alteration of some other rock of igneous origin. This kind of soapstone as it is called, is frequently studded with garnets sometimes half an inch or more in diameter. The rock is split out or sawed out into thin slabs which are used as headstones, hearthstones, and the like. The garnet bearing variety is mottled in a not unpleasing manner with these crystals. Another kind of soapstone is of a grayish brown color and is free from garnets, and has been used in the past by the Indians or former inhabitants of the state in the construction of utensils of various kinds, such as bowls, pots, jars, etc. Fragments of

this kind of pottery are to be seen scattered over the fields in dozens of places. A very perfect large bowl of soapstone was dredged out of the Tombigbee river a few miles below Demopolis by Mr. Eli Abbott, and is now in the cabinet of the University of Alabama. On Coon Creek, near the Tallapoosa river, in the county of the same name, there is an old quarry of this rock from which the Indians manufactured their utensils by shaping them out still attached to the parent rock, and when finished, splitting them off. Circular markings on the face of the soapstone mass show still where these finished products were broken away from the solid rock. Almost as a matter of course, this locality is associated with a tradition of an Indian silver mine.

Slabs of soapstone have been used from Chambers county for lining the lime kilns at Chewacla, for the facing of bake-ovens, and for the furnaces used for the concentration of copper ore at Wood's copper mine, the material for the last named use being obtained from the vicinity of the mines.

Lead Ore.

The only occurrence of galena of any consequence thus far known in Alabama, is in the Trenton limestone about five miles west of Jacksonville, in Calhoun county, where much work was done by the Confederate government during the Civil war. Traces of the old quarries are still to be seen, and fairly good specimens of the ore may be picked up around them. With the present perfected machines for concentrating ores it would seem that this deposit might yet be profitably worked, if only the quantity of the ore were sufficient to justify the erection of suitable plant. This can be ascertained only by the expenditure of much money. Very much of the lead ore of Southeastern Missouri is no richer than some which can be obtained from the Calhoun county mines. The subject is well worth testing.

Some small veins with galena have also been observed in the Knox Dolomite.

Loose pieces of pure galena may be found on the surface over the entire state, in localities where it could not possibly be in place. The fact that similar occurrences are noted in all the other states adjacent, has led to the inference that these loose specimens have been dropped by Indians and others who have

brought them from Missouri or other lead-producing states. There is not a county in Alabama where there is not a tradition of a "lead mine," said to have been worked by the Indians or early settlers, and the details of these traditions are infinitely varied.

Mineral Paints.

These are mainly the iron ores, the red, brown, and yellow ochres, and barite.

Ochres.—In the soft leached ore beds of the Chilton or Red Mountain formation, there are deposits of soft ore of greasy feel, free from grit, which makes a strong and most durable red paint, extensively used in the Birmingham Paint Works, and shipped from Attalla to Chattanooga to the extent of about 2,000 tons a year.

Some of the argillaceous shales of the limonite banks yield good yellow and red ochres; a fine red ochre of this kind occurring a few miles northeast of Talladega.

In the great clay formation of the state, viz., the Tuscaloosa of the Lower Cretaceous, are numerous deposits of both yellow and red ochres. Some of the yellow ochres have been mined and marketed from Autauga and Elmore counties, and a fine red ochre deposit of the same formation is known near Pearce's Mill, in Marion county. It must be borne in mind, however, that the above mentioned are only a few typical occurrences of these materials, selected out of hundreds that might be mentioned.

Overlying the St. Stephens limestone of the Tertiary, beds of good yellow ochre have been tested in Clarke county, and in the Grand Gulf territory of South Alabama also fine yellow ochre occurs in Barbour and other counties.

Barite.—The usual mode of occurrence of barite or heavy spar, is in boulders or irregular masses imbedded in the residual clays derived from the Trenton limestone, and in loose pieces on the surface. The most important localities are near Tampa, in Calhoun county, near Greensport in St. Clair, near Maguire Shoals on Little Cahaba River, at the "Sinks" on Six Mile Creek, and near Pratt's Ferry in Bibb; in all cases near the contact of the Trenton limestone with the Knox Dolomite.

The Alabama barite is of white, grayish and bluish colors, sometimes stained with iron on the surfaces. In the localities mentioned the barite is very pure and white; but it has not as yet, so far as known, been put upon the market from Alabama.

Tripoli or Polishing Powder.

Tripoli proper, the infusorial or diatomaceous earth or "fossil flour" of organic origin, occurs abundantly in many localities in the lower part of the state, e. g., in the recent swamp deposits near Mobile; in the Second Bottom deposits of the Alabama River at Montgomery; in the Buhrstone and Clayton formations of the Tertiary; the first two being of fresh water origin, while the Tertiary beds, containing marine diatoms and radiolaria, are of marine origin. In view of the fact that this material finds extended use in the covering of steam pipes, etc., it would be well worth while to investigate some of the occurrences more closely. Many details are given in the Report on the Costal Plain of Alabama.

Polishing powder of very different origin occurs in many localities in Northern Alabama. This is the result of the thorough leaching of the cherty limestones and dolomites of the Knox Dolomite of the Silurian, and of the Fort Payne division of the Lower Carboniferous. It is known as "rotten stone," and is a porous rock of finely divided siliceous matter. To fit it for use as a polishing powder it must be crushed, ground and bolted. The largest deposits are in Talladega and Calhoun and Lauderdale counties.

Some shipments have been made from the first named.

Copperas, Alum, and Epsom Salts.

These mineral salts occur in protected or sheltered places where the rocks contain iron pyrites, the weathering of which furnishes the sulphuric acid, and the country rock the iron, alumina, and magnesia. Such occurrences are most numerous in connection with the strata of the Devonian and Carboniferous formations, and are common in the open caves under overhanging rock ledges, known as "rock houses."

In the dark colored sandy clays of the Claiborne and next

underlying Tertiary formations, there are pyritous earths which have been put to commercial use in Choctaw, Washington, Clarke, Escambia, and other counties by leaching out the sulphates of iron and alumina and putting them on the market as "mineral extract," "acid iron earth," etc.

At Greenville, in Butler county, a strong solution of these acid sulphates is obtained from a shallow well, and is well known over the state as a medicinal agent.

Nitre.

The limestone caves of the northern part of the state contain large quantities of nitre, which during the civil war was obtained from this source for the manufacture of gunpowder. The marks of the picks then used are still to be seen plainly at some of the localities.

Although an organic substance, the bat guano, so abundant in many of the caves referred to, may be mentioned in this connection. This fertilizer contains 25 per cent. of organic matter, 6 per cent. of nitrogen, mainly in the form of uric acid, and from 1 to 3 per cent. of phosphoric acid, 1 to 3 per cent. of potash, and .6 per cent. of ammonia.

Phosphates.

Silurian Formation.—The phosphates of the Mount Pleasant, Tenn., district extend down into Alabama for two or three miles along Elk River and its western tributaries, Sugar Creek and Little Shoal Creek, into Limestone county. They also show along the state line for several miles to the east of Elk river, extending in places a quarter of a mile or more into Alabama. The geological horizon is probably Trenton, as in Tennessee. The phosphatic rocks do not outcrop over much area since they are usually in comparatively narrow valleys far below the general level of the country, but they underlie some large level tracts and second bottoms of the river and creeks, and are seen also covering hillsides. Exposures of more than 100 acres of these rocks occur along the line of the L. & N. railroad about a mile south of the state line.

There are two varieties to be distinguished, a friable, dark colored, porous, calcareous sandstone, and a light gray, friable, siliceous limestone. The former, derived from a siliceous dark blue limestone, weathering into flags from the fraction of an inch up to eighteen inches in thickness, occupies the lower 6 or 8 feet of the strata. The gray or upper phosphates are from 10 to 25 feet aggregate thickness, though it is not probable that all this thickness of strata is highly phosphatic at any one place. These are derived from a light bluish gray limestone that is often crystalline and that weathers into scales and flags from a fraction of an inch to two or three inches in thickness.

None of these phosphates, so far as they have yet been investigated, comes up to the grade of the Mount Pleasant rock; 75 per cent. of bone phosphate, though it is quite possible that future careful prospecting will discover them in Alabama. Small quantities of the rock have been mined about a mile west of Veto, on the L. & N. railroad.

Some 19 well weathered samples from this part of Alabama have been subjected to analysis with the result that 5 contained from 60 to 70 per cent. of bone phosphate; the others varied from 20 to 50 per cent. with one exception, and this contained less than 13 per cent.

The formations of the Coastal Plain at several horizons, hold beds of phosphatic materials which might well be utilized upon our soils.

Cretaceous Formation.—At the base of the Selma Chalk or Rotten Limestone division of this formation, there is a bed of phosphatic green sand in which occur irregular concretions and nodules of phosphate of lime.

In the disintegration of this bed the nodules of phosphate are left in considerable quantity scattered over the surface and represent in the aggregate, a very great quantity of the material, since the bed extends nearly across the state near or through Eutaw, Greensboro, Marion, Hamburg, Prattville, and Wetumpka. In no place, however, have they been found in sufficient quantity for profitable working.

On the other hand, the phosphatic green sands of this belt and of that next to be mentioned, are of nearly identical quality with the marls of New Jersey, which have been used with such

signal benefit upon the soils of that state, and there can be no doubt but that the application of these marls to the soils of Alabama, where such application can be effected without too great cost, would bring about a similar improvement with us.

At the summit of the Selma chalk occurs another bed of phosphatic green sand, with large percentage of carbonate of lime, which outcrops at least half across the state along the southern border of the Chalk, passing near Livingston, Coatopa, Linden, and other points eastward.

A few field tests have been made with both these marls and with most decided good results. We can, however, never expect their use to become general till the railroads are ready to transport them to points within the state at minimum rates.

Tertiary Formation.—Phosphatic nodules are known to occur in several of the divisions of the Tertiary, but in none as yet in quantity to make them of commercial importance. Shell marls, however, are abundant, and of easy access at many points in this region, and have been locally utilized.

Building Stones.

Limestones.—The best of these for building purposes are to be found in the Lower Carboniferous and Trenton formations, and quarries have been opened in Marshall, Colbert, Franklin, Bibb, Shelby, Jefferson, St. Clair, Talladega, Calhoun, DeKalb, and Etowah counties.

The best known are the quarries of T. L. Fossick & Co., at Rockwood, in Franklin county. The equipment at these quarries is very complete and extensive. The stone is from the Lower Carboniferous formation and it has been very largely used in the construction of the locks on the Tennessee River. The LaGarde Lime & Stone Company, at Anniston, have also an extensive plant, using the Trenton limestone, and there are several other quarries of less importance. The Trenton limestone has been used in the construction of the locks at Greensport, and the other sites on the Coosa river.

In the Tertiary formation of South Alabama some of the materials of the Lower Claiborne formation, especially an aluminous sandstone, have been utilized as rough building stones at many points. The St. Stephens limestone also is still more extensively used. This formation holds some beds many feet in

thickness, which are called "Chimney rock," from one of the principal uses made of it. This is a soft, somewhat chalky white rock, almost pure carbonate of lime, which is quarried by cross-cut saw, and shaped with saw, hatchet and plane. The principal use to which the blocks are put is the construction of chimneys and fire-places, for which, notwithstanding its composition, it is most admirably adapted, fire-places which have been in use for fifty years being still in a perfect state of preservation. In the region of its occurrence all across the state and also in the adjoining states, nearly all the chimneys and pillars to the houses are constructed of this rock.

Sandstones.—The sandstones of the Coal Measures, the Lower Carboniferous (Hartselle), and the Cambrian (Weisner), have all been used in building, and are well adapted to the purpose. In the Coal Measures quarries have been worked at Jasper and Cullman, and at Tuscaloosa. The locks on the Warrior River at the last named place are constructed of rock obtained from the bed and banks of the river. The Hartselle sandstone is quarried near Cherokee, Colbert county, and the stone has been used in the construction of the locks at the Colbert Shoals on the Tennessee River. The Weisner sandstone has furnished the material for many of the handsome buildings around Anniston.

Granites and Other Igneous Rocks.—While these rocks have not been much quarried in Alabama, they occur in great quantities and in position favorable for quarrying at many points in Lee, Tallapoosa, Chambers, Randolph, Elmore, Chilton, Coosa, Cleburne, and Clay counties. The granites outcrop in "flat rocks," which are low, dome-like masses of naked rock, sometimes 200 acres or more in extent. The largest of these flat rock areas are near Almond postoffice, in Randolph; near Blake's Ferry, and near Rock Mills, and Wedowee, in the same county; also near Milltown, in Chambers; southwest of Roxana, and along Sougahatchee Creek, in Lee. Smaller outcrops are to be found in all the other counties named. With the massive granites are associated the gneisses; both are most excellent building stones, and they are also suitable for monuments. The factories, dams, and bridge piers at Tallassee and vicinity have been constructed of the gneissoid granite, which makes the bed and banks of the Tallapoosa River there. Some use has been made of the granites about Wedowee in Randolph, at

Rockford and other places in Coosa, and rough stone has been used in the construction of the culverts and bridge foundations, etc. of the Central of Georgia Railroad in most of the counties of the metamorphic region traversed by it.

Paving and Curb Stones.—The flaggy sandstones of the Coal Measures and of the Red Mountain formation are very well adapted to these uses, and they can be gotten out in almost any desirable size. In some places these slabs are so uniform and numerous that they have received the name "plank rocks." The flags from the Red Mountain may be seen in the sidewalks and curbs of Birmingham.

Paving blocks are made from the hard flags of the siliceous limestones of the Tennessee Valley and shipped to Memphis.

Slates.

While in many localities in Shelby, Talladega, Calhoun, Cleburne, Clay, Coosa, and Chilton counties, there are great beds of slate which from their surface outcrops appear to be sufficiently promising, yet so far as we have information, they have been put to actual use only during the Civil War and for covering the Confederate arsenal building in Selma.

The slates mentioned belong to several geological formations, viz., The Talladega or Ocoee; the Weisner; and the Montevallo Shales of the Cambrian, and the upper Trenton of the Silurian.

Of these the best are perhaps the slates of the Weisner, occurring in the southwestern part of Talladega county; those of the Montevallo group in Chilton county; on Buxahatchee and Clear Creeks; and those of the Trenton in the "Dark Corner" northeast of Anniston in Calhoun.

Quarries have been started in several localities, but have been carried to no greater depth than 20 to 25 feet, not below the reach of weathering, so that adequate tests have not yet been made.

Sands.

Building sands are obtained from loose beds overlying the formations from which they have been derived; from the drifted sands along water courses; from the stratified sands of some of the newer formations, and from the harder sand-

stones of the older formations. The best of these sands which have yet come into use are obtained by crushing the friable sandstones of the older formations, especially of the Lower Carboniferous (Oxmoor) division. The material for the glass works at Gatė City, analyzing 99 per cent silica—is from this source, the rock being almost at the door of the works.

Sandstones of the Coal Measures and of the Weisner formation are also in places suitable, and in the Tuscaloosa division of the Lower Cretaceous, we also have an unlimited source of sands of every grade.

In the upper of the Cretaceous divisions, viz., the Ripley, there are numerous beds of excellent sands, some quite suitable for glass making e. g. from the vicinity of Linden in Marengo county.

So also in the Tertiary formation we find numerous beds of fine sands, such as occur for instance in the vicinity of Gaston in Sumter county, and further south, in the territory covered by the Grand Gulf formation, are extensive beds of all grades, in Washington, Mobile, Baldwin, Escambia, Covington, Geneva, Dale, Henry, Houston, etc. Travellers in that section do not need to be reminded of the prevalence of sand there. The Lafayette formation lastly, which mantles the entire coastal Plain is prevalently a sand and pebble formation; the sands being as a rule, ferruginous, but in many places quite suitable for building purposes.

Road and Ballast Materials.

The materials used in road making in Alabama are chert, quartz pebbles, and limestone, including dolomite.

The chert has probably been used more extensively than either of the others. It occurs in the Lower Carboniferous formation and in the Knox Dolomite of the Silurian. In the former it is generally in more or less regular beds or sheets, in the latter rather in the form of concretionary masses. The chert from both these sources has found extended use in several counties especially Jefferson, Calhoun, Talladega. That from the Lower Carboniferous formation contains a good proportion of carbonate of lime, and shows a tendency to harden on the surface, thus making an ideal road material. Extensive quarries are near Birmingham, Leeds, Anniston, Jacksonville, and other cities.

The rounded, waterworn *quartz pebbles* are abundant in the Lafayette formation, which is a mantle of sands and pebble covering more or less completely all the central and lower parts of the state. Usually the pebbles are imbedded in a red sandy clay which acts as a cement holding them in place and forming a road surface, scarcely if at all inferior to that made by the chert. In nearly every county of the state from Tuscaloosa to the Gulf, these clay pebble beds of suitable character occur, and there is no reason why any of these counties should lack good roads.

Broken limestone and dolomite, are the most common material in some of the counties of the Tennessee valley, and in parts of the Coosa valley, and the widely distributed limestones of the Lower Carboniferous and Silurian formations of the northern part of the state furnish an inexhaustible supply.

For *ballast,* all the above mentioned road materials have been utilized, and in addition to these broken up sandstones and furnace slags.

Millstones, Grindstones and Whetstnoes.

The conglomerates of several formations of the state, especially of the Weisner Quartzite, the Coal Measures and the Lafayette are capable of yielding good millstones, and locally they have been so used, and in the early days some of them had well established reputations.

For grindstones the sandstones of the Cambrian and of the Red Mountain and Coal Measures formations, have been found suitable, and certain thin laminated sandy shales of the Coal Measuers have served for whetstones of very good quality.

Asphaltum, Maltha, Petroleum, and Natural Gas.

The asphaltum and maltha here referred to are the solid and semi-solid products resulting from the desiccation of the fluid petroleums.

These and petroleum are most common in the Lower Carboniferous rocks of Russellville and Moulton valleys and of the southern slopes of the Little Mountain of the Tennessee valley region. They occur in the highly fossiliferous crinoidal limestones and the course-grained sandstones of the formation,

which are often saturated with them to the extent that they ignite when thrown into the fire. On the surfaces of these rocks the petroleum may often be seen in yellow drops, but generally these surfaces are black from the maltha or "tar," which on sufficient exposure hardens and oxidizes into asphaltum. Several car loads of the black bituminous sandstone from the top of the Little Mountain south of Leighton, were shipped to Memphis and the tar or asphalt there extracted. These substances were also extracted from the crinoidal limestones by boiling, and several barrels of the tarry matters were scooped up out of a drift.

These tar springs have been known for many years and they were formerly places of resort by the afflicted who drank the tarry water or took pills of the maltha.

Petroleum can be obtained from the same bituminous sandstones and limestones, and also from the Black Shale of the Devonian formation, which is usually sufficiently saturated with bituminous matter to burn or ignite when thrown into the fire.

Natural gas is quite common in many parts of the state, occurring as a rule along with salt water, sometimes with small quantities of petroleum accompanying, oftener without it.

Probably the most promising of the borings for petroleum are those put down in the Tennessee Valley region. The Goyer well No. 1 in the Moulton Valley, is said to have had at one time a capacity of 20,000 cubic feet of gas and 25 barrels of oil a day; the oil was of dark green color with a not unpleasant odor. This well was bored to a depth of 2,120 feet.

For some reason the oil flow was lost, and never recovered in paying quantity. Many other deep wells have been bored in different parts of the state, as well as in the Tennessee Valley region, but without success, so far as petroleum in commercial quantity is concerned.

Many of these borings have been made in the Southern part of the state, especially in Clarke, Washington, and Mobile counties, where there are so many salt wells and salt seeps. Salt water and natural gas in considerable quantity have been obtained from many of these wells, but as yet no petroleum in commercial quantity. At Cullom Springs in Choctaw county near Bladon, a deep well bored about 1886 was probably the first among the recent borings to show considerable amount of natural gas, but many of the old borings in the salt region

made during and before the Civil War, yielded along with the brine, large quantities of this gas. In places the gas and salt water rise to the surface in natural seeps.

Perhaps the most abundant supply of natural gas along with salt water comes from the wells lately sunk near the Bascomb race track in Mobile. Recent measurements of the flow of gas of these two wells, have shown it to be 35,000 cubic feet daily for each. As the water gushes from a four inch pipe to the height of six or seven feet it is such a foam of water and gas that it may be ignited and will frequently burn for several minutes till splashed out by chance fall of the water.

The salt wells of Clarke and Washington counties were of great value to the state during the war as source of that indispensable and at the time scarce substance, common salt.

Mineral Waters.

It would be impossible to enumerate all the mineral wells and springs of the state, even those which have a more than local reputation. They are to be found in all parts of the state and show great variety in quality. The following springs and wells either ship water to all parts of the state and outside of the state, or are places of resort with accommodations for visitors: Bailey Springs in Lauderdale County; Chocco Springs, Talladega county; Chandler's and Chambers' Springs also in Talladega; Piedmont Springs in Calhoun; Mentone Springs in DeKalb; all these have waters that are chalybeate or alkaline carbonate. Woolley or Millhouse Spring in Limestone; Johnson well in Madison; White Sulphur Springs in DeKalb; Blount Springs in Blount; St. Clair Springs in St. Clair; Shelby and Talladega Springs in the counties of the same names are all strong sulphur waters. Cullom and Bladon Springs in Choctaw county, were well known places of resort in former years, still much visited on account of their fine sulphur and vichy and other waters. The sulphur well at Jackson, Clarke county, gives a mild saline sulphur water which is not exceeded in palatability by any, unless it be that of a sulphur spring at the Lower Salt works near Oven Bluff.

Many of the artesian borings in the central and lower parts of the state give waters which are much used and which are

sent to all the markets of the state. Livingston in Sumter county is perhaps the best known of these. In the Flatwoods belt on the border of the Cretaceous and Tertiary formations, in Sumter county there are several shallow wells which yield strong *epsom salts* waters that have a wide reputation and are now extensively bottled and shipped. Of the same nature is the water from the Gary Spring near Centerville, in Bibb county, with a composition very nearly identical with that of the celebrated Tate Springs

The Ingram Lithia springs, Cook's Springs and others, have also wide reputation.

The Geological Survey of Alabama is now engaged upon a systematic investigation of the natural waters of the state and many chemical analyses are now available, though not yet published.

Note on Stone Quarries.

In addition to the quarries supplying cut stone for building purposes, mention may be made of quarries supplying rough stone only, viz.:

The *Killebrew Quarries,* two and a half miles east of Berry, Fayette county, on the Southern Railway, supply rough stone for the improvement of the Mississippi River; about 20,000 to 30,000 tons per annum. This quarry is equipped with crushers, and furnish broken stone suitable for ballast.

Messrs. Christie and Lowe, Ledule, Fayette county, also on the Southern Railway, are quarrying the same rock as the Killebrew, viz., sandstone of the Coal Measures, to be used on the jetties of the S. W. Pass, La. This quarry, opened in 1903, has shipped 50,000 tons of stone up to May 15, 1904.

SOILS.

It would be obviously out of place in a document like the present to attempt to give an account of the many soil varieties of the state and their adaptation to various crops. This subject has been treated somewhat in detail in our Agricultural Report, 1881-2.

But inasmuch as the soils constitute the most recent of our geological formations, they must be included among our mineral resources, and certainly no one of these mineral resources can be compared with them in importance and interest to every citizen of the state.

A general discussion of the soils, from the point of view of their geological relations seems, therefore, to be called for here.

Since the soils have been derived from the disintegration and decay of the older rocks, a geological map might, to a certain extent, serve also as a soil map, but these products of decomposition now rarely rest upon the parent rock, but have been removed more or less remotely from their place of origin, and after various admixtures have been redeposited upon foreign terranes with which they have no connection; again, many of the parent rocks of now existing soils have themselves in their turn been soils derived from still older rocks, have been deposited as sediments, compacted, elevated and again disintegrated and decomposed into soils. These are some of the difficulties which we meet with when we attempt to trace a soil back to its origin.

Another difficulty comes from the fact that soils from various sources have often very similar composition, for all soils are essentially the insoluble residues left from the weathering of older rocks, and these insoluble residues, from whatever parent rock derived, are mixtures in varying proportions of sand and clay, with small amounts of the soluble salts derived from these rocks and not yet completely leached out of the resulting soils. It follows, therefore, that soils from whatever source derived, will differ from each other *mainly* in the relative proportions of the sandy or siliceous and the clayey constituents.

It should be borne in mind, further, that in consequence of the highly absorptive and retentive qualities of clay, the relative proportions of lime and of the elements of plant food in the soils, such as potash, phosphates and the like, will in great measure depend upon the amount of the clayey constituent, so that the classification of soils into *sandy* and *clayey* carries with it far more than this primary distinction.

As a broad generalization, it may be said that residual soils, *i. e.*, those which have not been far removed from the parent rock, exhibit the widest variations, while the transported or drifted soils are more uniform in composition. And furthermore, the greater the distance the transported soils have been carried from their place of origin, and the oftener they have been taken up and redeposited, the more complete is the separation of the clayey constituents from the sand, and the more complete is the leaching out of the soluble salts upon which in great measure the fertility is dependent. All this is illustrated in the changes to be observed in the soils as one goes from inland towards the coast.

For convenience in the discussion of its soils, the state may be divided into two parts, approximately coextensive with the Mineral District and the Agricultural District, respectively.

In the first, the soils are in the main, *residual, i. e.*, they have been derived from the rocks upon which they now rest, and show, therefore, more or less close relationship to them. In the second, the Coastal Plain or Agricultural District, the Cretaceous and Tertiary formations have been overspread with a mantle of sandy loam and pebbles, *transported* from elsewhere, and the soils are in great measure made from these materials, modified, however, locally by admixtures with the disintegration and decomposition products of the underlying older rocks.

The Mineral District.

As before stated, the soils of the Mineral District are mostly residual in their nature, and while the parent rocks are sandstones, shales, and limestones, each of these is varied by admixtures with the others, and to such a degree as to give rise to a great variety in the resulting soils. The three principal varieties are here given, but it will be understood that

they grade into each other in such a way that the actual number is far greater.

1. *Sandy Loams, in part slightly calcareous.*—These are derived from the sandstones and siliceous shales of the Coal Measures, the Weisner Quartzite, and the Talladega Slates: from the cherty or more siliceous parts of the Knox Dolomite, and of the Lower Carboniferous Limestones; and from some of the Montevallo Shales. Naturally these soils are less fertile than the others, but on the other hand, they lie well, are easily cultivated and responsive to fertilizers. Perhaps 10,000 square miles of the Mineral region have soils of this kind.

2. *Calcareous Sandy Loams.*—In these the proportion of clay and by consequence, of lime, is greater than in the preceding class; the soils are inherently more fertile, and quite as easy of cultivation and as responsive, and hence form the most desirable farming lands of this section. They cover about 4,000 square miles of territory and are the residual soils from the slightly siliceous limestones of the Tuscumbia division of the Lower Carboniferous, the Fort Payne Chert, the lower beds of the Knox Dolomite, and the more calcareous of the Montevallo Shales, and the rocks of the Red Mountain group. The fine red lands of the Tennessee Valley, those of parts of the great Coosa Valley, and belts in the other anticlinal valleys are of this character.

3. *Highly calcareous clayey soils.*—These occupy some 2,500 square miles of area, and are derived from the purer limestones of the Lower Carboniferous, and of the Trenton, and from the calcareous shales of the Flatwoods. The parent rocks appear along steep hillsides or else in flat, badly drained valleys, and the soils are in consequence generally too rocky or too wet for cultivation; and while essentially fertile, they are of comparative little value as farming lands.

The Coastal Plain.

The upland soils of the Coastal Plain, as has been intimated, are in the main based on the materials of a single formation, the Lafayette, which as a mantle of sandy loam and pebbles has been spread over the entire district with an average thickness of 25 feet. When unmodified by admixtures with

the underlying country rock these Lafayette soils are at their best highly siliceous loams, usually of deep red color from iron oxide. They are well drained, well situated and among the most desirable of our farming lands, because of these qualities and of the ease of working and capability of improvement. At the other extreme they are very sandy and comparatively infertile in the natural state, yet some of the most valuable truck farms of Southern Alabama have soils of this class

While the Coastal Plain formations, Cretaceous and Tertiary, consist prevalently of sands and clays in many alternations, yet there are two great limestone formations intercalated, viz., the Selma Chalk and the St. Stephens Limestone, the former of Cretaceous, the latter of Tertiary age.

The Selma Chalk is about 1,000 feet in thickness, is a rather soft chalky rock carrying from 10 per cent. to 50 per cent, clayey matters, the middle third of the formation holding from 10 per cent. to 25 per cent. of clay, while the upper and lower thirds contain larger amounts.

The St. Stephens Limestone, in its lower part, is also an argillaceous clayey limestone much like the Selma Chalk, but the upper part is a purer rock containing only on an average about 10 per cent. of insoluble matters.

Now in those parts of the Coastal Plain where the underlying country rocks are sands and clays, the resulting soils from these do not differ essentially from the surface loams of the Lafayette itself, and needs therefore no special mention.

But in those belts on the other hand, where the limestones of the Selma Chalk and of the St. Stephens underlie and constitute the country rocks, the soils show marked departure from the prevailing type of Coastal Plain sandy loams. From these areas the Lafayette sands have often been in great part swept away by erosion, and the soils are in a measure residual, being the insoluble clayey residues from the decay and disintegration of the limestones.

Like all clayey soils derived from limestones, they are of exceptional fertility, and make the very best farming lands of the state. Such are the soils of the great Black Belt or Canebrake Belt of Central Alabama, and those of the Lime Hills, and Hill prairies of the southern part of the state. Remnants of the Lafayette mantle occur at intervals through all

these regions, and admixtures of the red loams of this mantle with the native marly soils, give rise to many varieties, such as the *Red Post Oak soils*, the *Piney Woods Prairie soils*, etc.

Another departure from the prevailing Coastal Plain sandy loams is caused by the great clay formation of the Lower Tertiary, which gives origin to the *Post Oak Flatwoods* of Sumter and Marengo counties. East of the Alabama River in Wilcox and Butler counties, these clays hold much lime and form regular "prairie" soils, characteristically developed along Prairie Creek in Wilcox.

Besides the above, there are small areas of marly soils in the Tertiary, due to the shell beds which occur at intervals in the lower or lignitic division of this formation. Of this kind are the celebrated Flat Creek lands of Wilcox, marled by the outcrop of the Woods Bluff greensand shell bed, which is also responsible for fertile lands on Beaver Creek, the same county, on west side of the river, and on Bashi Creek in Clarke county.

The Nanafalia shell bed or marl also is responsible for many tracts of fertile limy soils in Marengo and Wilcox.

In the lower counties of the state the materials of the Lafayette are in general more sandy than is the case further north, and we find in this section also another surface mantle, viz,. the Grand Gulf, underlying the Lafayette, and like it consisting mainly of sands with some beds of laminated clay intercalated.

By reason of this double mantle the thickness of the sandy surface beds is much increased, so that the Miocene limestones, which are known to underlie this section, seldom if ever come to the outcrop and influence the soils except along the immediate banks of the Chattahoochee and possibly of some of the smaller streams. In all this region which is gently rolling or nearly flat, shallow ponds, pine barren swamps, and open savannahs are characteristic of the landscape, due, so far as we can make out, to the uneven surface of the Grand Gulf clays which underlie the Lafayette sands at shallow depths These beautifully situated, high, level lands are characteristic of parts of Baldwin and Mobile counties, and are destined to become valuable farming lands when lumbering and turpentining shall cease to give chief occupation to

the population, and this, from present prospects, will soon happen since the pine has been cut off or destroyed by fire over very much of the territory.

Bottom Soils. Along all the larger streams of the Coastal Plain region we find developed normally three well defined terraces. The ***first terrace*** or bottom is subject to overflow and its soils are the sands and other materials periodically deposited by the stream, and are the most recent perhaps of the formations. A few feet above the high water mark and consequently not subject to overflow except in the depressions caused by erosion, are the ***second bottoms,*** with very characteristic soils, yellowish silty loams increasing in sandiness from above downwards. The second bottoms are on an average perhaps a mile in width, and are always choice farming lands. Upon this terrace are many of the great plantations of ante bellum days.

About 100 feet above the second bottom we find a ***third terrace*** averaging some three miles in width, the soils of which are of the usual Lafayette type, red sandy loam underlaid by pebbles. On this terrace are situated most of the river towns such as Tuscaloosa, Selma, Cahaba, Claiborne, St. Stephens, Jackson, Columbia, etc. The soils on this terrace are not essentially different from the Lafayette soils elsewhere, unless possibly they are a trifle more sandy. Above this third terrace at varying elevations are the broad level uplands making the interstream country of the Coastal Plain, and it is upon these uplands that we find the most characteristic and widely distributed of the soils of this region based upon the red sandy loam of the Lafayette.

GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, PH. D.
State Geologist

BULLETIN No. 10

RECONNOISSANCE REPORT

ON THE

FAYETTE GAS FIELD

ALABAMA

BY
M. J. MUNN
Geologist, U. S. Geological Survey

Prepared in co-operation with the United States Geological Survey.

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BROWN PRINTING COMPANY,
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Montgomery, Ala.
1911.

LETTER OF TRANSMITTAL.

To His Excellency,

EMMET O'NEAL,

Governor of Alabama.

Sir:

I have the honor to transmit herewith, the manuscript of a Reconnoissance Report on the Fayette Gas Field by M. J. Munn, Geologist, U. S. Geological Survey, with the recommendation that it be printed as Bulletin No. 10 of the Alabama Geological Survey.

Very respectfully,

EUGENE A. SMITH,

State Geologist.

University of Alabama,

July 10, 1911.

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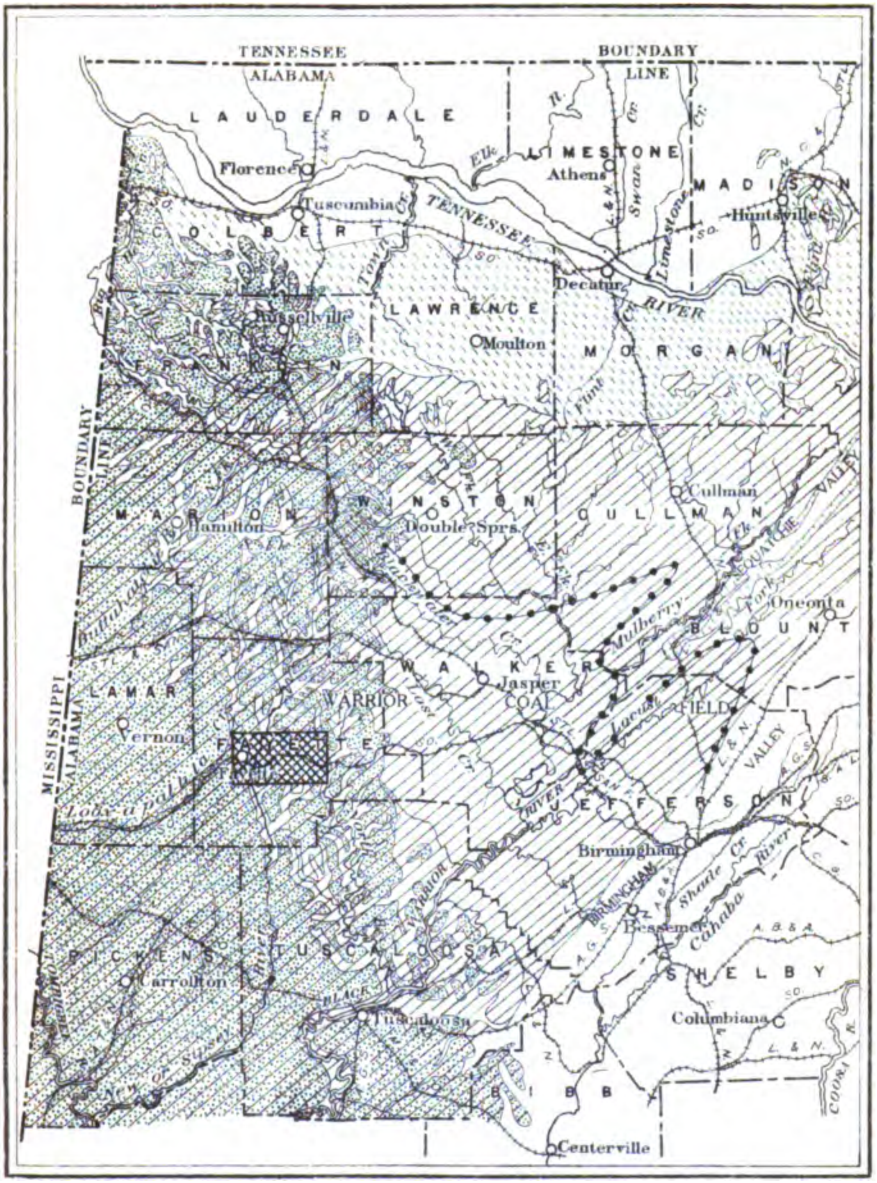


SKETCH MAP OF NORTHWESTERN ALABAMA

Showing location of area mapped in the Fayette Gas Field, the general structure of the region and the northern and eastern extent of the Pennsylvanian Series of rocks in which the gas is found.

Scale 1 inch = 25 Miles

0 25 50 75

LEGEND

Cretaceous and younger beds overlying Carboniferous rocks of both the Pennsylvanian and the Mississippian Series.

Rocks of the Pennsylvanian Series (Coal measures) and approximate outcrop of the Black Creek coal.

Rocks of the Mississippian Series, including Pennington Shale, Bangor Limestone and Hartselle Sandstone member.

Area mapped in the Fayette Gas Field.

RECONNOISSANCE REPORT ON THE FAYETTE GAS FIELD, ALABAMA.

INTRODUCTION.

Location of the Fayette Gas Field.—The Fayette gas field as developed on February 1, 1911, consists of three deep wells in which gas occurs in commercial quantities and three other wells that, having furnished considerable gas, may prove to be profitable. All these wells are situated in the valley of Sipsey River, about 2 miles east-southeast of Fayette, Fayette county, Alabama.

Discovery and Development of the Fayette Gas Field. Development work in this vicinity was begun early in 1909, when a diamond drill hole was put down at what is now Gas Wells station in search for coal. This hole was bored to a depth of 475 feet encountering two or more sandstones that furnished small quantities of oil. These indications led to the drilling of two deep test wells, for oil and gas, adjacent to the diamond drill hole. On December 20, 1909, one of these wells encountered a gas-bearing sandstone at a depth of 1,400 to 1,420 feet, and began producing gas at an estimated rate of 1,600,000 cubic feet per day, the gas having a closed pressure of about 630 pounds to the square inch. This well was drilled by the Eureka Company which was afterwards merged with the Providence Oil and Gas Company, and the well is now known as Providence well No. 1. The other test well, located about 30 yards from the Diamond drill hole, was sunk by the Providence Oil and Gas Company to a depth of about 1,685 feet. In it oil and gas were reported in small quantities from several horizons, but the well was a failure.

Shortly after the completion of well No. 1, several other wells were started. One of these, known as Providence well No. 8, reached the gas sand March 1, 1910, and began producing at a rate estimated to be about 4,500,000 cubic feet per day. This is said to be the best well in the field. Providence well No. 6 was completed about April 15, 1910, finding gas in paying quantities. The initial capacity and the closed pressure of this well are not known to the writer. Its daily capacity has been estimated at between 2 and 3 million cubic feet and

the present (Dec. 1, 1910) closed pressure is said to be about 580 pounds. Providence well No. 3, located about a half mile from the railway station at Fayette, was completed in April, 1910, to a depth of about 2,200 feet. Aside from several "shows" of oil and gas this well is reported to have furnished an initial flow of about 150,000 cubic feet of gas from a depth of about 1,400 feet. The well was abandoned. Providence well No. 9 was completed about June 1, 1910, with a reported daily capacity of about 800,000 cubic feet. This well is said to have furnished salt water from the gas-bearing sand, as does Providence well No. 10, which was drilled later. The latter is said to have furnished a strong flow of gas until shot with 80 quarts of nitroglycerine after which the salt water increased so much in quantity and head as to greatly reduce the capacity. Four wells within a few thousand feet of the center of the gas field, and six others at distances of 1 to 20 miles from it, had been drilled to various depths, or were being drilled at the time of the writer's last visit, Dec. 8, 1910. At that time none of these were producing oil or gas in commercial quantities.

Purpose and Scope of this Report.—This report and its accompanying maps are the result of a co-operative agreement between the Alabama Geological Survey and the United States Geological Survey, by which each organization contributed funds for field work, and the Alabama Survey met the expense of publication.

The chief objects of this work were first to prepare a good topographic base map suitable for use of both the geologist and the oil producer; and, second, to make a preliminary study of the geologic structure of the rocks of the gas field and vicinity for the purpose of determining as far as possible the nature and extent of the folds in the strata and to see if geological work of value to the oil and gas producers could be done in advance of the drill.

The geologic work was entirely of a reconnoissance nature, and, owing to the limited funds available, it was confined principally to an attempt to locate the larger folds and other structural features by spirit level lines along the outcrops of recognizable beds. The writer did not attempt while in the field to correlate the outcropping rocks of this region with those of better known localities to the east, and the broad tentative cor-

relations that have been made in this report are based largely upon the evidence published in previous reports and that furnished through the courtesy of other geologists who have studied portions of the region.

Field work for the topographic map was done between October 1, 1910, and February, 1911, by Mr. R. H. Reineck, assisted by Mr. J. M. Rawls, both of the U. S. Geological Survey.

Methods employed in field work.—As a base for the vertical control of the topographic map the top of the north rail at the railroad crossing in front of the station at Fayette was calculated from railroad levels to have an elevation of 359 feet above mean low tide. From this bench mark, level lines were run by planetable and telescopic alidade to every part of the area mapped. The mapping was of a somewhat detailed reconnoissance nature, consisting of flying level lines and stadia traverse over nearly all of the roads, and tape traverse and barometer elevations through the wooded area between the roads. No astronomical observations were made for latitude and longitude, the traverse lines being adjusted upon closed circuits. The section and township lines were determined by locating some of the section corners on the map and platting the unlocated ones from distances given for each line from notes obtained from the General Land Office. The farm lines were compiled from the county records by Mr. E. C. Janney, attorney, Birmingham, Alabama, who kindly furnished these data at a nominal charge.

Geologic work was begun by the writer October 9, 1910, and was discontinued for want of funds December 9. The lack of a suitable base map at the beginning of the work necessitated the running of stadia traverse and level lines by the writer over much of the eastern quarter of the work. These traverse and level lines were carried over most of the roads and to all points in the interior where favorable rock exposures were to be found. The dip of exposed beds was determined principally by level lines along their outcrops. The traverse and level lines and such topographic sketching as was done in connection with the geologic work were later used for the topographic base map.

Acknowledgments.—The field work upon which this report is based was done under the general direction of Dr. Eugene A.

now the Atlantic and Gulf Coastal Plain. Over the Warrior coal field these unconsolidated beds are thinnest along their northeastern border. The plane of contact between the Carboniferous and overlying Cretaceous beds dips southwest at a low angle and the latter become correspondingly thicker in that direction. The southwest extent of the coal-bearing rocks in the Warrior field is unknown, since the plane of contact between them and the Cretaceous lies far below the deepest valleys in Western Alabama and in Mississippi, and very few deep wells have been drilled to it, but inasmuch as most of the series is present at the Cretaceous margin at Fayette, it is highly probable that the "Coal Measure" rocks extend far to the southwest under the Cretaceous and Tertiary rocks of the Coastal Plain.

The Fayette gas field is located at a point where the plane of contact between the Carboniferous and Cretaceous rocks is at or just below the valleys of the streams, the Carboniferous beds being exposed at rare intervals in narrow strips along the base of the valley walls, the loose Cretaceous rocks covering the hills to a maximum depth of 200 or 300 feet. Since no oil or gas has yet been found in the Cretaceous beds of the Warrior field, no detailed attention need be given to them. From the data in hand, it seems almost certain that the sandstone furnishing the large flows of gas at Fayette belongs to the lower portion of the Pennsylvanian series, and it is therefore important in this report to give more attention to the general distribution of this and the underlying formations which may contain valuable accumulations of oil and gas at favorable places within the Warrior field.

STRATIGRAPHY.

General Stratigraphy of the Warrior Coal Field.

Our knowledge of the stratigraphy and structure of the greater part of the Warrior coal basin in Alabama rests upon the most excellent reports by Henry McCalley, whose last great work was the "Report on the Warrior Coal Basin," published by the Geological Survey of Alabama* in 1910.

*See also a report on the Geology of the Warrior Coal Field published by the Geological Survey of Alabama in 1886.

Although the field examinations by Mr. McCalley were made without the aid of topographic base maps, and with limited facilities for precise work, his large map, which extends to the Fayette district, has, so far as tested by later and more detailed observations, revealed a high degree of accuracy and value, and it long will continue the best and most reliable source of information regarding the greater part of the region. The subdivisions of the coal measures given in McCalley's text and map have been adopted by Butts in the Birmingham folio and are employed in the present report.

The rocks not exposed at the surface in the Fayette gas field have been studied to a limited extent in well sections to a maximum depth of about 2,350 feet, below which no well has yet penetrated. The possibility of there being lower strata favorable in composition and character for accumulations of oil and gas is of importance to those interested in the development of the field.

The nearest exposures of formations underlying the Pennsylvanian series are along Birmingham and Sequatchie valleys to the east and northeast. On the western side of Birmingham valley the rocks have been upturned and faulted in such manner as to expose thousands of feet of strata which extend westward under the "Coal Measures" to an unknown distance. (See generalized sections, Pl. II, in pocket). These exposures furnish the best means of determining in advance of very deep drilling the nature of the formations lying below the bottom of the deepest well in the Fayette district and therefore will be briefly discussed below.

ROCKS EXPOSED ALONG THE EASTERN BORDER OF THE WARRIOR COAL FIELDS.

PRE-CARBONIFEROUS ROCKS.*

The oldest and stratigraphically the lowest beds exposed along Birmingham valley consist of 1,000 to possibly 1,500 feet of thin-bedded blue limestone interbedded with gray or yellow shale, of Cambrian age. Above them are about 3,300 feet of Knox dolomite, which comprises about 600 feet of

*The data contained under this heading are taken very largely from chapters by Chas. Butts in Bull. 400, U. S. Geol. Survey.

thick-bedded, non-cherty, gray, crystalline dolomite at the base, (Ketona dolomite member) overlain by as much as 2,800 feet of thick-bedded crystalline dolomite with chert in beds, nodules, and stringers.

Unconformably upon the Knox dolomite is a dove-colored to blue, generally thin-bedded, limestone, from 300 to 500 feet thick, of Ordovician age, which, in previous reports of the Geological Survey of Alabama has been called the Pelham limestone, and which is called Chickamauga limestone by the U. S. Geological Survey.

The Silurian rocks of this region are represented by the Clinton ("Rockwood") formation which overlies the Pelham or Chickamauga limestone unconformably. It is composed of varying amounts of gray and yellow shale; green, brown and red sandstone, and beds of limy red iron ore with a total thickness of 200 to 500 feet.

The Devonian system, which is thousands of feet thick in the northern Appalachians, in this region is generally represented by only a few feet of black Chattanooga shale. In places the Devonian rocks also include the Frog Mountain sandstone, which is 20 feet or less in thickness and underlies the Chattanooga shale. Over a large portion of Alabama, Tennessee, and Kentucky the Chattanooga shale is less than 30 feet and rarely exceeding 100 feet in thickness. At almost every point where it outcrops or has been pierced by wells this black shale has been found to be more or less petroliferous, but in a very few places is the oil and gas to be found in paying quantities. East and north of the Warrior coal field the Devonian rocks lie unconformably upon the Clinton formation and also are separated by an unconformity from the Carboniferous system above.

Carboniferous Rocks.

The Carboniferous rocks exposed in Sequatchie and Birmingham valleys are several thousand feet in thickness. These are separated in two great series; the Mississippian series below and the Pennsylvanian series above. Since all of these rocks are probably within reach of the drill in the Fayette gas field, they will receive more attention in this report than the underlying formations which have been described above.

Mississippian Series.

Note—In order that the relations of the formation names of the Mississippian series used in this report, to the names heretofore in use in the reports of the Alabama Geological Survey may be clearly understood, the following note is deemed necessary. To the northward of Birmingham the strata of the Subcarboniferous or Mississippian series, between the Fort Payne chert below and the base of the Coal Measures above—prevalently limestone but with subordinated shales and sandstones,—have received the name Bangor. A somewhat persistent bed of sandstone, accompanied with some shale, separating two great bodies of limestone of this formation, has been called the Hartselle sandstone. These limestones, sandstones and shales in the geological position indicated, constitute the Bangor phase of the Mississippian or Subcarboniferous as used by the Alabama Geological Survey, since 1891.

To the southward of Birmingham the strata occupying the same geological position, namely, between the Ft. Payne chert below and the base of the Coal Measures above—prevalently shales and sandstones with subordinated beds of limestone—have received the name Oxmoor. The Oxmoor of the south and the Bangor of the north have been deemed by the Alabama Survey as equivalents in time but with lithological variations due to geographic positions.

The name Oxmoor should be retained in the Alabama reports as a formation name, since it has priority, and it should be well understood that it includes the Floyd, Pennington and Parkwood of the U. S. Geological Survey authors, in so far at least, as the Parkwood is of Mississippian and not Pennsylvanian age. The only objection made to the use of the term Oxmoor comes from the fact that some of the authors of the U. S. Geological Survey have used it in a restricted sense to designate a particular bed of sandstone which they have placed below the Bangor and above the Floyd, while as a matter of fact the Bangor is a formation contemporaneous with the Oxmoor but in a different locality and with correspondingly different lithological character. The Floyd is merely a synonym of part of the Oxmoor.

No doubt some of the limestones in the Oxmoor area may be found to be actually continuous with some of the great limestone beds of the Bangor area, but it will not do to place the Bangor at the top of the series with the Oxmoor sandstone next below it and the Floyd shale below the Oxmoor as has been done by one of the writers, nor to place the Bangor in the lower part of the Floyd and ignore the term Oxmoor altogether, as has been done by another writer, especially when the use of the term Oxmoor by a writer of the U. S. Geological Survey, in a different sense from that in which it is used by the members of the Alabama Geological Survey, is made the reason for discarding the term Oxmoor. On this principle it would be possible to throw out any well established name.

To designate somewhat clearly defined lithological variations in the strata of the Mississippian series between Ft. Payne chert and Coal Measures in certain localities, as for instance in Shades Valley southward of Birmingham, the terms Parkwood, Pennington and Floyd might be used with advantage and no objection is made to their use if it be understood clearly that they together make up the Oxmoor formation of that section, in the sense in which that term has been consistently used in the Alabama reports.—E. A. S.

In this region the Mississippian series is separated into four formations, which, in ascending order are: Fort Payne chert, Bangor limestone (including the Hartselle sandstone member), Pennington shale, and Parkwood formation. So far as known all the Parkwood and part of the Pennington are wanting in the Warrior field, so that there is an unconformity between the Mississippian and Pennsylvanian series in that area, the base of the Pennsylvanian series lying upon Pennington shale at a horizon near its bottom.

Fort Payne chert.—The Fort Payne chert, which includes the Tuscumbia limestone and Lauderdale chert of previous Alabama State Survey reports, consists of 125 to 250 feet of yellowish chert in thin layers ranging from a few inches to two feet in thickness. This chert is very hard and brittle, and, where unexposed to weathering and but slightly fractured by deformation, it will probably prove to be a zone of hard drilling, the great hardness of the material wearing the bits rapidly. This is a very persistent formation and most probably extends throughout the Fayette gas field. Because of its whitish color in drillings and its hardness, it may be mistaken by drillers for a sandstone, but its association with the soft black petroliferous Chattanooga shale below should render it recognizable by drillers.

Bangor limestone.—The formation known as the Bangor limestone has an average thickness of about 700 feet. It is composed predominantly of limestone, but also contains much shale and sandstone. The limestone is generally light gray in color, very pure, crystalline, and thick-bedded. In places thin beds of red or gray shales and clay occur near the top. The limestone of this formation is separated into two well marked divisions by a very persistent sandstone about 100 feet thick, which occurs about 200 feet above the base of the formation. This bed, known as the Hartselle sandstone member, varies from fine-grained and hard, to coarse and friable, and in places contains a thin layer of fine conglomerate. Along Birmingham valley north of the vicinity of Birmingham, and in Sequatchie Valley, the Bangor limestone has the general character named above. South of Birmingham the limestone phase disappears and the formation is principally shale with the Hartselle sandstone member growing thinner toward the south. The Bangor limestone and the Pennington shale are equivalent to

the Floyd shale south of the latitude of Birmingham. Studies by Charles Butts* have revealed other variations in the Mississippian series from north to south along Birmingham Valley, which will be briefly discussed later.

Pennington shale.—In Murphrees Valley, and along the western side of Birmingham Valley, and where it comes to the surface along the Sequatchie anticline in Blount county, the Pennington shale consists of 50 to 100 feet of gray shale, locally containing thin layers of red and green shales and a little chert. East of Birmingham in Shades Valley the Pennington is about 300 feet thick and consists of dark red, black and gray shales, a little chert, some pink shaly sandstone, and some fine conglomerate. South of Birmingham, on the western side of the valley, the Pennington shale and Bangor limestone pass into the Floyd shale.

Floyd shale.—As stated above, the Floyd shale occurs south of Birmingham on both sides of Birmingham Valley at least to the place where the Mississippian rocks pass beneath the Cretaceous sand and gravel. It was deposited contemporaneously with the Bangor limestone and Pennington shale north and northwest of Birmingham. The Floyd is largely shale, gray, black, or pink in color. It contains some fine-grained sandstone, a few thin layers of limestone, and a little fine conglomerate. The Hartselle sandstone member passes unchanged from the Bangor limestone at the northeast into the Floyd shale at the southwest and is present wherever the Floyd comes to the surface on the western side of the valley southwest of Birmingham. Southward from Bessemer on the southeast side of the valley this sandstone member disappears. The Floyd has a thickness of 1,000 to probably 1,200 feet. Attention is called to the probable character of this portion of the Mississippian series in the vicinity of the Fayette gas field. From the data now available, it seems probable that the belt of transition from Pennington shale and Bangor limestone to Floyd shale may pass westward from the vicinity of Birmingham in the general direction of the Fayette gas field. For this reason there is some uncertainty as to whether the Pennington shale and Bangor limestone, or their equivalent, the Floyd shale, are present there. The probable depth at which these

*Bull. 400, U. S. Geol. Survey, pp. 18-20, and U. S. Geologic Atlas, folio No. 175, Birmingham quadrangle.

rocks will be encountered at Fayette is discussed under the heading "Unexposed Rocks in the Fayette District."

Parkwood formation.—In Shades Valley, east of Birmingham, the Pennington shale is overlain conformably by the Parkwood formation consisting of 2,000 feet of sandstone and shale. Sandy shale, either green or gray, predominates in this formation. Thin-bedded sandstones up to 100 feet in total thickness are common. Unlike the other lower Mississippian rocks, the Parkwood contains no limestone, and is practically destitute of fossils. This formation is present north and east of Birmingham but absent along the whole length of the western side of Birmingham Valley and also in Sequatchie Valley, and it seems probable that it is also wanting throughout the Warrior field, including the Fayette district. In this region there is a stratigraphic hiatus or unconformity of possibly 2,000-3,000 feet between the Mississippian series ("Sub-Carboniferous") and the Pennsylvanian series (Upper Carboniferous or "Coal Measures").

PENNSYLVANIAN SERIES.

Pottsville formation.—Overlying the Mississippian series along the Birmingham and Sequatchie valleys there are about 2,600 feet of Pottsville shale, sandstone, clay, and coal. East and southeast of Birmingham in the Cahaba and Coosa coal fields the Pottsville strata are much thicker, reaching a maximum of about 7,000 feet. The base of this formation is exposed on both sides of Birmingham Valley and along the northeastern and northern border of the Warrior coal field. Rocks of Pottsville age form the surface of the coal field southwest to where this formation disappears beneath the Cretaceous sand and gravel in the vicinity of Fayette.

Though incomplete sections of Pottsville rocks have been studied by geologists in various parts of the Warrior coal field, there is little information available to show whether the whole formation tends to thicken or to thin, from the eastern and northern edges of the basin toward the Fayette gas field. The Pottsville beds thicken from north to south along their exposures at the eastern margin of the Warrior coal field, and they appear to thin somewhat along the northern margin from east to west. The effect of these two opposing tenden-

cies upon the thickness of this formation in the Fayette district could be determined only by a careful correlation of the coal beds across this territory and a study of fossils from deep core drill holes in the Fayette district. The evidence collected to date suggests a slight thinning of the Pottsville in that region.

In the Birmingham region the lower third of the Pottsville formation carries thick strata of siliceous sandstone known as "millstone grit"; in the middle third sandy shale predominates; while the upper third is marked by a considerable proportion of sandstone of a feldspathic type rather than of the siliceous type characterizing the lower third. All of the coal beds of the Alabama fields occur in this formation. Though more or less coal is found throughout the formation, the thickest and most valuable beds are in the upper two-thirds.

Near the base of the Pottsville formation, east of Birmingham Valley, are two very persistent sandstones, the Shades sandstone member below and the Pine sandstone member above. Each of these sandstones ranges from 100 to probably 600 feet in thickness. The Shades and Pine sandstones are coarse, siliceous and conglomeratic at the base, grading into fine-grained, more thin-bedded sandstones above. Near the base of the Shades sandstone is the horizon of the Brock coal bed.

On the eastern edge of the Warrior coal field the Boyles sandstone member, believed to be equivalent to the Pine sandstone member, is the basal member of the Pottsville resting unconformably upon Mississippian rocks. The Boyles sandstone member is a white or gray siliceous sandstone, in places conglomeratic at the bottom. It is the "Millstone grit" of the Warrior coal field. Overlying the Boyles sandstone member are about 600 feet of sandy shale and thin-bedded to massive sandstone up to the base of the Black Creek coal group. Within this interval three coal beds are generally recognized. These are in ascending order, the Tidmore, Rosa, and Sapp, which respectively lie 20, 140, and 370 feet above the top of the Boyles sandstone.

The Black Creek Coal Group consists of the Black Creek, Jefferson, and Lick Creek beds, which occupy an average interval of about 75 feet.

About 80 to 260 feet above the Black Creek coal group is the Mary Lee coal group which consists of the Ream coal bed, the Lick Creek sandstone member, and the Jaggar, Blue Creek, Mary Lee, and New Castle coal beds, and occupies an interval of about 180.

About 300 feet of shale and thin beds of sandstone separate the Mary Lee group from the Pratt coal group above. This group consists in ascending order of the Gillespie, Curry, American, Nickel Plate, or Cardiff, and Pratt coal beds, within an average vertical distance of about 130 feet. Above the Pratt coal bed for about 275 feet are shale and sandstone up to the Cobb lower coal, which is separated by about 20 feet of shale and sandstone from the Cobb upper coal bed. The Gwin coal bed overlies the Cobb upper at about 130 feet, and about 180 feet above the bed is the base of the Brookwood coal group, consisting of the Carter or Johnson beds at the base and Milldale and Brookwood beds above, the group occupying an interval of about 90 feet. About 200 feet of sandstone and shale completes the section of Pottsville rocks exposed along the southeastern margin of the Warrior coal field.

Though some of the sandstones that occur in this formation are fairly persistent, most of them vary greatly in thickness and texture from point to point. The shale is commonly very sandy, and frequently upon fresh exposure presents the appearance of thin-bedded, argillaceous sandstone. Probable correlations of beds of this formation with those encountered in the deep wells in the Fayette district are discussed below.

Unexposed Rocks in the Fayette District.

GENERAL STATEMENT.

The nature, character, and thickness of the rocks underlying the surface of the Fayette district are not well known. A few facts relative to them have been obtained by a study of some of the upper beds at places where they outcrop in this district and adjacent to it, but by far the larger part of the present knowledge of them has been obtained from the logs of deep wells, drilled in search of oil, gas, and coal. All of the logs of these wells that have been obtained have been platted

to scale, and arranged on Plate II with reference to their geographic position and the height of the mouth of each well above sea level.

Difficulty in making correlations from well records.—A careful study of Plate II (in pocket) will make evident the fact that well logs of churn drills cannot be relied upon for detailed correlations, for the reason that in drilling only the well-marked changes in character of the beds can be detected with certainty even by trained observers. By this method only the general character and sequence of the beds may be used as a guide in correlation, the very valuable paleontological evidence furnished by the fossils of the beds being destroyed in drilling. Unfortunately, core drills have not yet penetrated the rocks of this district to a sufficient depth to furnish the paleontological data so greatly needed. The greatest single source of error in making correlations from churn drill logs lies in the fact that all drillers, from the nature of the business, do not have a uniform system of identifying and naming the rocks which they encounter. Each driller, therefore, names the pulverized material brought up by the bailer according to his own standards. Errors in making and in noting measurements to the strata encountered, and the failure at times to detect the presence of thin coal beds, especially if they are encountered in soft black shale, also tend to render less valuable the use of well logs in correlating rocks of widely separated districts.

PENNSYLVANIAN SERIES.

POTTSVILLE FORMATION.

With the exception of a comparatively thin covering of sand, clay, and gravel, of Cretaceous and younger age, the rocks penetrated by the drill in the Fayette district appear to belong entirely to the Pottsville formation. This conclusion is based largely upon a comparison of the coal beds and prominent beds of sandstone of the well sections with the generalized section of the Pottsville formation where it is exposed on the eastern edge of the Warrior field. For convenience of comparison attention is directed to Plate II.

Correlation of coals of the well sections.—In well section F ten coal beds have been reported which appear to fall into groups similar to the generalized section of the Pottsville formation. By assuming that there is a general decrease in thickness of the Pottsville westward from Birmingham Valley, which is generally thought to be probable, the most prominent group of coal beds in well Section F, composed of coal beds numbered 28, 30, 32, and 34, appears to correspond somewhat closely with the Mary Lee coal group of the generalized section. On this basis of comparison the lowest of this group, No. 34, may be equivalent to the Ream bed; the Jaggar bed may be either No. 32 or No. 30; and No. 28 either the Blue Creek coal bed or the Mary Lee bed. The fact that a fairly persistent sandstone separates the Blue Creek and Mary Lee beds in the generalized section, together with the distance between beds, suggests that No. 28 is more nearly equivalent to the Blue Creek bed. If this is true coal No. 19 in well section H, which overlies a sandstone, may be the Mary Lee bed, in which case the Newcastle coal, if present, has not been recorded in the well sections.

Below this coal group in well section F occur two coal beds, Nos. 38 and 42, which are comparable, respectively, to the Lick Creek and Black Creek coals of the Black Creek coal group. The distance between these two groups in well section F and the generalized section are practically the same. The interval from the Black Creek coal to the Sapp coal in the eastern part of the Warrior field averages about 230 feet, in comparison with 160 feet between what is assumed to be the Black Creek coal and the next one below (No. 49) in well section F, thus leaving the identification of the latter in considerable doubt.

In the generalized section the Pratt group of 5 coal beds occupies an interval of about 130 feet and lies 300 feet to 430 feet above the top of the Mary Lee coal group. In well section F two coal beds, Nos. 13 and 20, occupy an interval of 130 feet at a distance of 300 to 430 feet above the four coal beds of this section, which appear to be comparable in part at least to the Mary Lee group. These also appear to be the same as coal beds Nos. 12 and 17, respectively, of well section C, and possibly coal beds Nos. 7 and 11 of section A. Unfortunately, the upper 475 feet of section F is not available,

nor the section of the Brennen core drill hole located a few feet distant from Providence well No. 5. The few scattered coal beds reported in the upper part of the wells are doubtfully correlated as follows:

If it is assumed that the tentative identification of the Mary Lee group of coal beds in the Providence well No. 5 (section F) is correct, coal No. 5 of this well section, and coal No. 14 of well section G (Providence well No. 1) seem to occupy a position about 550 feet above the Mary Lee group, or about 125 feet above the Pratt coal group of the generalized section. The thin coal No. 15 of the Providence well No. 5 (section H) may belong to the same horizon, but appears to be somewhat higher. These coal beds seem to be too low to belong to the Cobb coal group, and to be somewhat too high for the Pratt group, though the presence of the thick sandstone No. 7 below this coal in section F suggests that an increase in interval between the Pratt coal and the Nickel Plate coal may, in the Fayette district, bring the former up to this horizon. The Cobb coal group appears to be represented by coal beds Nos. 5, section A; 6, section C; 11, section D; 13, section H; and 12, section L.

The Gwin coal bed, which in the generalized section is shown about 140 feet above the Cobb upper coal, appears, from the above correlation, to be represented by coal No. 4 of section C, and the small lens of coal near the base of sandstone No. 8, section E. The Carter or Johnson coal appears to be present in section D as coal No. 5; in section I as coal No. 9, and in section L as coal No. 8. If this correlation of the Carter or Johnson coal bed is correct, the Milldale coal above it is not represented in the well sections, the Brookwood coal being shown only as No. 3 of section H. In section H sandstone No. 5 is equivalent to sandstones Nos. 2, 3, and 4 of section G; sandstone No. 3, of E; sandstone No. 2, and the upper part of No. 3 of section D; sandstone No. 1, of section C, and No. 2 of section B. It probably lies above the top of section A. In sections I and J the top of this sandstone is in contact with the basal conglomerate of the Cretaceous, and in the river bluff at Providence well No. 4 (section C). A correlation of the outcropping beds based upon the identification of this sandstone in areas where it is exposed is made in the chapter on the "Areal distribution and character of the outcropping rocks."

These tentative long-distance correlations are, of course, made suggestively only. They might have been made more conclusive if the positions of more coal beds in the well sections were known. At best they will very likely be subjected to considerable revision when a sufficient fund of paleontologic evidence has been accumulated, or the records of suitably distributed wells are available.

Correlation of the other strata of the well sections.—In this report no attempt will be made to correlate in detail the strata reported in the deep wells. However, in all attempts to trace a horizon from place to place by well records alone, it is best to remember that the tendency of drillers is to report greater thickness of sandstone than actually occur. Many hard, compact beds of sandy shale are mistaken for sandstone, because the appearance of the pulverized material from such beds generally shows a large percentage of sand grains, the beds offer relatively great resistance to drilling, and the wear on the bits is similar to that produced by sandstone. In well section K the relatively great thickness of sands Nos. 10 and 12, as compared with the other well logs, strongly suggests that those beds are made up principally of compact, sandy shale in which occur numerous thin beds of sandstone. Also in well section A, the beds Nos. 3, 14, 16, and 20, characterized by the driller as "Limes," "broken lime," etc., are most probably not limestone at all, but somewhat calcareous shale and sandstone.. No. 3 of this section is very probably a calcareous sandstone. Also, Nos. 17, 22, and 23 of well section B, though probably containing a noticeable amount of lime carbonate, most likely would not be classed by the drillers themselves as limestone if the beds were exposed at the surface.

The sandstone found to contain gas in paying quantities in Providence well No. 1 is known as the Fayette gas sand. This sand is shown at the base of sections G, H, I, and K, and is sandstone 26 of section L. There is doubt as to the position of this sand in the well near Kennedy, as shown by section M. The elevation of this well was not obtained and the tentative correlation based upon stratigraphic sequence alone suggests sandstone No. 18 as being equivalent to the Fayette gas sand, but it is possible that sandstone No. 18 of section M is the same as either sandstone No. 22 or 24 of section L.

Numbers 40 to 43 inclusive of section F are very probably equivalent to the Fayette gas sand, as are also numbers 18 to 20 inclusive of section B, and No. 22 of section A. Sandstone No. 31 of section D appears to overlie the Fayette gas sand, but the nature of the log leaves this in serious doubt.

The very thick sandstones, Nos. 28 and 29 of well section L. appear to be equivalent to sandstones 25 to 31 inclusive of well section A, and the shale beds Nos. 26, 28, and 30 of well section A seem to be absent in well section L. The exact position in the Fayette district of the sandstone in the generalized section of the Pottsville formation on the eastern edge of the Warrior field is somewhat in doubt. If the Fayette gas sand is one of the sandstones of the Black Creek coal group, as correlated above, the very thick sandstones shown at the base of well sections A and L may be correlated with the shale, sandstone, and coal of the generalized section from a short distance below the Black Creek coal to and possibly including some of the Boyles sandstone member. A very massive sandstone is locally found below the Black Creek coal at places along its outcrop on the northern side of the Warrior coal field, and this sandstone may increase in thickness southwest across the coal field, becoming several hundred feet thick in the western part of the Fayette district, and possibly uniting at base with the Boyles sandstone member. The absence in well section L of the three beds of shale, Nos. 26, 28, and 30, of well section A, suggests thickening of the sandstones of this horizon from east to west.

As already stated, the Boyles sandstone member of the eastern side of the Warrior coal field is tentatively correlated with the Pine sandstone member of Birmingham and Cahaba valleys, east and northeast of Birmingham. The stratigraphic position of this sandstone is shown on the generalized sections of the rocks of these valleys, at the bottom of Plate II.

Probable Character of the Rocks Below the Wells of the Fayette District.

A very important factor which must not be overlooked in considering the nature of the beds to be found below the wells in the Fayette district is the unconformity* at the base of the

*The Birmingham folio, No. 175 U. S. G. S. by Charles Butts.

Boyles sandstone on the eastern side of the Warrior coal field. This unconformity represents a long period of time during which the Mississippian rocks constituted a land surface and were being removed by streams. Along the northeastern edge of the Warrior coal field this hiatus includes all of the Pottsville formation below the Boyles sandstone member, say 500 feet; all of the Parkwood formation, say 2,000 feet; and all but about 60 feet of the Pennington shale, say 200 feet, in all 2,700 feet. The Boyles sandstone member thus rests directly upon the eroded surface of the Pennington shale. If similar conditions prevailed in the Fayette district, the drill would penetrate only a few feet of red, gray, green, and black shale below the Boyles sandstone member before entering the Bangor limestone, or its equivalent, the Floyd shale. This unconformity may be either greater or smaller in the Fayette district than on the eastern border of the basin. If the former is true all of the Pennington shale and even the Bangor limestone or the Floyd shale may have been removed from the old land surface before the sea again covered this region and the deposition of the Pottsville sandstones began.

If the unconformity decreases in magnitude from the northeastern edge of the Warrior coal field toward the Fayette district, all of the Pennington shale (shown in the generalized section at the bottom of Plate II) may be present, and under this formation the Bangor limestone or its equivalent part of the Floyd shale in its full thickness. If geologic conditions were similar in the Cahaba and Fayette districts during the deposition of the rocks below the Pine sandstone member, then the beds should be prevailingly shaly for about 500 feet below the Boyles sandstone member, and the next 500 to 700 feet of strata should be made up principally of the massive, siliceous, conglomerate Shades sandstone which forms the basal member of the Pottsville formation in Cahaba Valley east of Birmingham. It seems very doutbful if the Parkwood formation is present in the Fayette district, since it thins rapidly westward from the Cahaba Valley, and is absent along the eastern side of the Warrior coal field. If the Parkwood is present, it probably is very much thinner than it is in Cahaba Valley, and probably consists largely of sandy shale.

The Pennington shale and Bangor limestone are very probably present in the Fayette district, but there is no means of

predicting whether or not these phases of sedimentation or that of their equivalent, the Floyd shale, occurred there. If all of these formations are present, they probably have a combined thickness of 1,000 to 1,200 feet. The Fort Payne chert and the underlying formations, as shown in the generalized sections of Plate II, are widespread and are most probably present in the Fayette district.

It seems probable that the section below the "Coal Measures" of the Fayette district is the same as that part of the generalized section for Birmingham Valley, beginning 100 feet above the base of the Pennington. The depth to the Hartselle sandstone or Chickamauga limestone or any other desired horizon very probably can be computed from the generalized section of the Warrior coal field and the section in Birmingham Valley by assuming that the bottom of the Boyle sandstone member lies 50 to 100 feet above the bottom of the Pennington.

Exposed Rocks in the Fayette District.

As stated above, the rocks exposed at the surface in the Fayette district are separable into two great systems, the Carboniferous below and the Cretaceous above.

At the close of the Carboniferous deposition this region was elevated above sea level forming a land area from which material was removed by the streams and deposited in the surrounding sea. This continued throughout the Triassic and Jurassic time, but near the beginning of the Cretaceous period the land sank and in the water which covered it sand, gravel, and clay from the adjacent land areas were deposited. Thus the surface of unconformity represents the time during which this was a land area and no material was being deposited upon it.

Because of folding in the Carboniferous beds previous to the deposition of the Cretaceous strata the bedding planes of the latter were not laid down parallel to those of the former, but lay across or unconformably upon the eroded edges. Because of this unconformability, the folds in the Cretaceous beds give no clew to the character and amount of or disturbance in the Carboniferous rocks lying below. In this district gas is found only in the Carboniferous rocks, and in order to determine accurately the positions of the anticlines and

synclines in them not only good exposures of the rocks uniformly over the area to be mapped are required, but also some of the beds must have such characteristics as will afford a means of identifying them at all places where they are exposed.

Two colors are used on the map to distinguish these general subdivisions of the outcropping rocks,—blue for Carboniferous, green for Cretaceous and Tertiary, the uncolored portions representing alluvium and wash of Recent age. No attempt has been made to differentiate portions of the Cretaceous, Tertiary and Recent beds, since such a differentiation is of no value in an investigation of the oil and gas possibilities of the district.

AREAL DISTRIBUTION AND CHARACTER OF OUTCROPPING BEDS.

POTTSVILLE FORMATION.

Although Carboniferous rocks of Pottsville age are present within about 400 feet of the surface at all points in the area covered by the topographic map, the beds actually come to light in relatively small portions of it. These exposed areas are at such places where streams have cut through the Cretaceous and Tertiary blanket of sand, gravel, and clay, which once covered the entire surface, into the Carboniferous strata below. In places the streams have laid bare Pottsville beds over considerable stretches of valleys. At many of these places the older rocks have since been covered by thin deposits of alluvium and wash from adjoining hill slopes, thus effectively concealing them from view. On the map the portion colored blue represents areas in which Carboniferous beds have been seen, though a thin mantle of unconsolidated material, usually sand, covers the Pottsville strata over most of each area. A brief description of the exposures of Pottsville rocks noted in these areas is given below.

In reconnoissance work ahead of topographic mapping, where, as in the present case, all lines of traverse were run out and plotted in the field, the time available for field work did not permit the tracing of outcrops throughout their entire length. Because of the well known tendency of sandstone beds to change rapidly in thickness and character from

point to point, there is a possibility of error in identification. For this reason it seems best to describe the exposures examined in such way that any errors of correlation that may have been made can be easily located by those who study the area in more detail.

Exposures of Pottsville rocks on Clear Creek.—Carboniferous strata are exposed along both sides of the valley of Clear Creek from its mouth as far north as the valley has been mapped, a distance of about 4 miles. The floor of the valley is alluvium which conceals the Carboniferous rocks, except at a few places along the banks of the stream.

On this creek, a short distance below the road crossing in Sec. 2, T. 16 S., R. 11 N., the following is exposed from the top of the bluff down to the creek:

CLEAR CREEK VERTICAL SECTION, SHOWING OUTCROPPING ROCKS.

Concealed at top of bluff		Ft.	Inch.
(1)	Sandstone, very thin-bedded, greenish and shaly	6	
(2)	Shale, brownish, compact, sandy	8	
(3)	Sandstone, or sandy shale, very compact, greenish	12	
(4)	Concealed with shale and sandstone debris	18	
(5)	Sandstone or sandy shale, thin-bedded, greenish to brown	5	
(6)	Sandstone, massive, medium-grained, cliff-making, greenish to brownish	10	
(7)	Concealed	15	
(8)	Sandstone, reddish brown, 5-foot massive, cliff-making ledge in the middle	12	
(9)	Concealed (brown shale, and some thin-bedded sandstone debris)	21	
(10)	Shale, bluish to brown, blocky, sandy	10	
(11)	Coal		14
(12)	Underclay yellowish brown, sandy	4	
(13)	Shale, black to dark blue, coarse, to water	5	
(14)	Sandstone in bed of creek		
	Total	127	2

A short distance up the creek above the road crossing the lowest sandstone (No. 14) shows for 10 feet above water level. It is here very massive, somewhat coarse, reddish to gray in color, and is overlain by about 20 feet of sandy shale which weathers brown at the base, but is somewhat more bluish at the top. A small coal bed (No. 1) occurs in this shale about 15 feet above the top of the sandstone. About

42 feet above this coal on the hillside a thin, cliff-making sandstone is well exposed. This sandstone may be traced in continuous outcrop to where it crosses the public road ⅛ mile west of the creek. At that point no coal was seen, but a thin bed of soft, white, red and dark clay, about 24 feet below the sandstone may mark the horizon of the coal bed. At this exposure the upper cliff-making sandstone is represented by a badly weathered sandy shale or shaly sandstone, the massive layers having disappeared. The outcrop of the sandstone below the coal bed (No. 14) was traced northward along the west side of Clear Creek for half a mile in continuous outcrop, where it was found to consist of 16 feet or more of massive, coarse, gray, cliff-making sandstone at the top and about 10 feet of thinner-bedded, somewhat shaly sandstone below. This sandstone is here underlain by about 8 feet of dark brown, sandy shale to the level of the creek which appears to be flowing over a thin sandstone.

The above section on Clear Creek is a fairly typical one for the exposed Pottsville beds in the area mapped, and, since it covers that portion of the geologic section most frequently exposed, it may be used as a basis for local correlation. Northward from this exposure the sandstone of the Clear Creek section becomes more massive, and is exposed at many places along Clear Creek in almost vertical cliffs from 10 to 50 feet high.

At the road crossing on Clear Creek at Cottons Mill, Sec. 35, T. 15 S., R. 11 W., the top of what appears to be sandstone No. 14 of the Clear Creek section outcrops about 45 feet above water level. This bed is here about 30 feet thick with a massive cliff-making ledge 3 feet thick at the top and another 10 feet in thickness near the bottom. About 20 feet of brown shale in which are imbedded thin sandstones underlie this sandstone down to creek level. The rocks are unexposed for 40 feet above this sandstone along the road west from the bridge, and the coal bed of the Clear Creek section is not visible. The first rocks exposed above are 5 feet of whitish to blue clay shale outcropping in a spring by the roadside. Overlying this shale for 15 feet are poor exposures of thin-bedded sandstone. A thousand feet farther west on this road and about 50 feet higher up the hill is 10 feet of coarse, massive, reddish to whitish sandstone, very deeply weathered, overlain

by Cretaceous sand. This appears to be sandstone No. 6 of the Clear Creek Section.

On the road one-third of a mile southeast of Cottons Mill, the lower portion of sandstone No. 14 of the Clear Creek Section is exposed in the road in front of a house. About 100 feet farther east a coal bed, possibly that of this Section, is also exposed on a level with the standstone. The coal is only a few inches thick, with a yellowish to whitish under clay about 4 feet in thickness. Below the clay is 20 feet of light brown, somewhat fissile shale on the top of a massive sandstone in the bottom of the adjacent ravine. The abrupt change at this place from sandstone to clay, coal, and shale strongly indicates a fault. If the sandstone is No. 14, and the coal the same as that of the Clear Creek section, the downthrow of the fault is to the east, the displacement being between 40 and 60 feet. For want of time the writer was unable to trace the outcrop of this sandstone along both sides of the valley and thus definitely correlate it with the beds described in the Clear Creek section.

At the bridge over Clear Creek, one mile east of Bankston, the massive sandstone below the coal in the Clear Creek section is probably just below drainage. This coal horizon apparently is marked by shale debris which covers the surface for about 30 feet above the creek. The first stratum exposed along the road west from the bridge is a dark brown, sandy shale which outcrops from 30 to 85 feet above the creek. Within this shale are a few thin layers of greenish, shaly sandstone and a 10-foot bed of thin-bedded, compact, greenish sandstone or very sandy shale which is 60 to 70 feet above the creek. This appears to occupy the same position as sandstone No. 8 of the Clear Creek section. From 85 to 100 feet above the creek is a greenish to brown blocky shale showing concretionary weathering, which is overlain by 8 feet of cliff-making sandstone, the lower 6 feet of which is very massive. This is sandstone No. 6 of the Clear Creek section. Above this sandstone the rocks are concealed except occasional small outcrops of sandy shale and thin-bedded greenish sandstone. On this road, northeast from Clear Creek, the strata described above outcrop and, though deeply weathered, are easily correlated. Here sandstones Nos. 5 and 6 of the Clear Creek section appear to be at least 25 feet thick with massive beds towards the top. They

are so badly altered by weathering that the contact between the carboniferous beds and the overlying Cretaceous sand cannot be determined with certainty. Northward along the ridge road some of the beds come to the surface in a few poorly exposed outcrops, which offer little opportunity for making accurate correlations. In N. W. ¼ of Sec. 1, T. 16 S., R. 11 W., a coal was encountered in a well dug for water, which appears to be the same as the one in the Clear Creek section. About 50 feet above it a massive cliff-making sandstone layer 5 feet in thickness outcrops along the hillside. Below this sandstone are a few small exposures of brown, sandy shale, containing occasional thin layers of greenish to reddish sandstone. Overlying this sandstone to the top of the hill is deeply weathered debris of sandstone and reddish sandy shale mixed with Cretaceous sand. Half a mile north of this locality a 4-inch coal bed is reported to be in a gully about 100 yards east of the road forks. A thin bed of white clay was found at this place but the coal, if present, was concealed. This bed is 40 feet higher than the one in the well. The character of the surrounding exposures is such as to make it doubtful if these two outcrops are of the same coal. The latter may prove to be a higher coal than the former and to occur at the horizon of the white clay mentioned as being exposed in the road near the Clear Creek section.

On the west side of Clear Creek, about half a mile north of the railroad, the cliff-making sandstone No .4 of the type section forms a well-marked cliff along the edge of the flat-topped hill. Below this is 10 feet of dark brown, sandy shale, which shows concentric weathering, and then a distance of 18 feet in which the rocks are concealed. Below the concealed part is 10 feet of greenish, thin-bedded, compact, cliff-making sandstone or very sandy shale, which shows well-marked joint planes similar to No. 8 in the Clear Creek section. Underlying this sandstone is 18 feet of yellowish brown shale poorly exposed which in turn overlies about 5 feet of thin-bedded, greenish, cliff-making sandstone. The remainder of the section down to creek level is concealed by debris and alluvium. The horizon of the coal of the Clear Creek section is a short distance below the lowest sandstone exposed at this point. At the railroad cut through the southern end of the hill the lowest cliff-making sandstone, which is probably below No. 8 of the

Clear Creek section, appears to be partially exposed about 50 feet above the track, and 20 feet of dark brown, somewhat fissile, sandy shale is exposed in the cut. The upper half of this shale contains a few thin layers of shaly sandstone. This shale is probably equivalent to No. 10 of the Clear Creek section. It is much thicker and the horizon of the coal bed of the Clear Creek section is above the cut.

At the first cut on the railroad east of Clear Creek about 10 feet of yellowish brown shale with thin sandstone layers is exposed at the base of the cut, which may be equivalent to the upper part of the shale, described above, in the railroad cut on the west side of Clear Creek valley. This shale is overlain by 10 feet of darker brown sandy shale free from sandstone beds and weathering in concentric concretion-like layers. About 40 feet above the track 5 feet of rather massive sandstone with thin-bedded sandstone below appears to be the equivalent of No. 8 of the Clear Creek section.

From this railroad cut David White secured a small collection of fossil plants which, though not sufficient for close cerrelation of these beds, suggest to him that the beds are later than the Pratt coal group, and possibly as young as Brookwood.

About ¼ mile south of this exposure, at the iron bridge where Clear Creek empties into North River, the sandy dark brown and bluish shale with thin layers of sandstone extends for about 40 feet above water. Overlying it is 7 feet of rather massive, cliff-making sandstone, with 8 feet of sandy brown shale above, to a second 8-foot massive layer of cliff-making sandstone, probably No. 8 of the Clear Creek section.

Exposures of Pottsville rocks on Deadwater Creek.—In the N. E. part of the N. E. ¼ of the S. E. ¼ of Sec. 33, T. 15 S., R. 11 W., a coal bed 10 or 12 inches thick is exposed at the base of the hill near the mouth of a tributary to Deadwater Creek from the north. The following section obtained at this point is used in correlating the exposed strata of the vicinity with those described in Clear Creek Valley.

THE DEADWATER VERTICAL SECTION SHOWING OUTCROPPING ROCKS ON DEADWATER CREEK.

		Thickness Feet
Cretaceous sand at top of hill		
(1)	Sandstone, thin-bedded, shaly, greenish, or very sandy shale, containing a few thin, more resistant beds of sandstone	42
(2)	Sandstone, massive, gray to brownish, cliff-making, weathers to coarse, light yellow sand	9
(3)	Concealed by sandstone debris from massive bed above	11
(4)	Sandstone, massive, gray, cliff-making	4
(5)	Concealed by boulders of sandstone from above	10
(6)	Sandstone in massive, cliff-making layers	3
(7)	Concealed by sandstone boulders from above	10
(8)	Sandstone, massive, cliff-making bed in two or three layers	5
(9)	Concealed by sandstone boulders from above	27
(10)	Shale, blocky, sandy, bluish brown at top to very dark brown at bottom	6
(11)	Coal, about	1
(12)	Clay, yellowish, sandy, fossiliferous	2
(13)	Dark brown blocky shale	2
(14)	Concealed below level of tributary valley	7
	Total	139

Sandstone No. 8 of the Deadwater section seems to be at least a part of No. 8 of the Clear Creek section, but the latter may include also everything between Nos. 4 and 8 of the Deadwater section, since all of these sandstones appear to thicken from north to south across the area mapped. Sandstone No. 2 of the Deadwater section is probably equivalent to sandstone No. 6 of the Clear Creek section, though this bed may also thicken to include Nos. 3 and 4 of the former. Numbers 1 to 5 inclusive of the Clear Creek section appear to be equivalent to all or a portion of No. 7 of the Deadwater section. From the data at hand the coal noted in the Deadwater section appears to be the same as that given in the Clear Creek section. The associated beds of shale and clay are very similar and the positions of the cliff-making sandstone layers above, together with the general appearance and character of each, add strength to this correlation.

A tributary of Deadwater enters the valley at the point where the Deadwater section was measured. On this stream two other coal outcrops were noted, one in the N. W. ¼ of Sec. 34, on a small tributary about ¾ mile northeast of the

outcrop noted in the Deadwater section, and another west of the stream at a spring in the central part of the N. W. ¼ of the S. E. ¼ of Sec. 28, T. 15 S., R. 11 W. These three outcrops appear to belong to as many different coal beds. The second one mentioned seems to overlie sandstone No. 8 of the Deadwater section; the one exposed in the spring is probably about 15 or 20 feet above sandstone No. 2 of that section.

The coal in Sec. 34 is exposed at one place in the valley where it has been mined in a small way by stripping the thin covering of Cretaceous wash. It is said to have a total thickness of 18 inches of solid coal of good quality overlain by 4 inches of shale, above which is two inches of coal. This bed appears to rest upon a coarse massive gray to greenish sandstone (probably No. 8 of the Deadwater section), 10 feet of which is exposed in the stream below the outcrop of coal. This sandstone appears to dip down stream at a rate almost equal to the fall of the stream and it seems to be the massive 20-foot sandstone exposed at the stream forks ¼ mile west. On the hillside about 50 feet above this coal outcrop a ledge of massive gray sandstone 6 feet thick protrudes from the Cretaceous sand. This appears to be sandstone No. 2 of the Deadwater section.

From the exposure at the forks of the stream ½ mile north of the place where the Deadwater section was measured, the massive, cliff-making sandstone has been traced in almost continuous outcrop northward to the coal exposure at the spring in the central part of the N. W. ¼ of S. E. ¼ of Sec. 28, T. 15 S., R. 11 W. This coal outcrop is now concealed in a bog below the spring, but it has been stripped by the owner of the land for local use. The bed is about 8 inches thick and is overlain by about 6 feet of soft bluish clay shale.

From a study of the exposed rocks between the coal outcrop in the spring and the Fayette gas field, it seems that sandstone No. 2 of the Deadwater section is probably equivalent to the massive sandstone exposed in the cut at Gas Wells station, and also the same as No. 5 of well section H. Pl. II, in which case the coal in the spring is equivalent to coal No. 3 of well section H, which has been tentatively correlated in the study of these well sections with the Brookwood coal. If this is a correct correlation, the coal described above as exposed on the small tributary in the N. W. ¼ of Sec. 34 is

probably the Milldale bed, the coal of the Deadwater section being the Carter or Johnson bed. This correlation, it should be observed, does not agree with the conclusions reached by McCalley who* considers the coal exposure along the Deadwater and Clear creeks to be the Cobb coal group.

It is to be regretted that sufficient paleontological material is not available to make possible a positive identification of these coal beds. An examination by David White of a few small collections of fossil plants obtained from a horizon a short distance below the coal bed of the Deadwater section, which he considers to be younger than the Pratt coal group, and probably not later than the Brookwood coal, still leaves unsettled the question of whether these coals belong to the Cobb group or to the Brookwood group. The writer's correlations of these coal beds is by no means satisfactory to himself, but are presented as a suggestion that they may prove to belong to the Brookwood group rather than the Cobb group.

It is possible that a fault occurs between the coal outcrop of vertical section B and the coal exposure to the northeast in Sec. 34, but no direct evidence of such fault was seen in the field, possibly because the rocks in the place in which it seems most likely to occur are concealed by wash from the adjacent hills. If this fault is present, it crosses the stream less than ½ mile north of the location of the Deadwater section, with a north-northwest-south-southeast trend, and the downthrow is probably to the southwest with a displacement of about 75 feet. Attention is called to the possible existence of this fault in order that too much reliance may not be put in the structure contour lines in this locality until it has been examined more thoroughly than was possible in the time allotted to this work.

At the mouth of a small tributary of Deadwater Creek from the west, the cliff made by the massive portion of sandstone No. 8 of the Deadwater section is only a few feet above valley level. About 100 yards southwest of this outcrop, sandstone No. 2 of the section is exposed at the top of a bluff on the south side of this tributary. Here the interval between these beds is composed very largely of sandstone, most of

*McCalley, Geol. Survey of Alabama, Report on the Warrior Coal Basin, 1900, pp. 169 and map.

which is thin-bedded, but here, as at most other exposures of these beds, the cliff-making portions are represented by harder, more massive layers. Sandstone No. 2 is exposed for ½ mile west along this tributary to where it passes below stream level. Sandstones Nos. 4 and 6 are also present here in typical outcrop.

At the forks of Deadwater Creek in the central part of Sec. 33, sandstone No. 8 of the Deadwater section outcrops on both sides of the valley near the base of the bluffs. It also outcrops northward along the east fork, for more than ½ mile before going under cover. Sandstone No. 4 of this section caps the tops of the bluffs on one or both sides of the stream as a somewhat massive cliff-making, grayish sandstone, for about 1½ miles. At some places along this outcrop the cliff-making qualities of the bed disappear and its outcrop is concealed by Cretaceous wash from above. This bed can be traced, however, with certainty to where it goes under drainage in contact with the Cretaceous.

Sandstone No. 4 of the Deadwater section is also exposed along the west fork of Deadwater Creek for about ¾ mile. It goes under cover at a point where sandstone No. 2 of the same section is exposed in the bluff above it. Number 2 is here a gray, cliff-making sandstone, which may be traced in uninterrupted exposure for a half a mile upstream where it passes below valley level in contact with the Cretaceous sand.

South of the location of the Deadwater section no good exposures were observed on the east side of Deadwater Creek valley for about ½ mile. In the S. W. ¼, Sec. 34, a small tributary enters Deadwater Creek from the east, and along the steep bluffs of this stream the rocks from sandstones Nos. 2 to 8 inclusive of the Deadwater section are exposed in continuous outcrops for ¾ mile. Here, practically the whole interval is made up of sandstone, but the massive cliff-making zones are sufficiently prominent to admit of a close correlation. Midway between this stream and where the Bankston-Fayette road crosses the valley exposures of sandstone Nos. 6 and 8 of this section were noted at the mouth of another small tributary from the east. North of this road, about halfway between Deadwater Creek and the cross roads on the hill to the east, sandstone No. 2 is exposed near the top of a small secondary ridge. This outcrop is traceable to another

exposure of sandstone No. 2 on the road just west of the above cross roads. On the west side of Deadwater Valley cliffs of sandstone are frequent. Tributaries to this creek from the west have cut deep narrow gorges near their mouths through sandstones Nos. 2 to 8 inclusive of the Deadwater section, the more massive of the sandstones appearing as cliffs. These exposures do not extend up the smaller streams more than a few hundred yards before they pass under the Cretaceous cover.

An exposure of sandstones Nos. 2 and 4 occurs on the Fayette-Bankston road about half way up the western side of the valley. At this place the following section was noted:

ROCKS EXPOSED ON FAYETTE-BANKSTON ROAD ON WEST SIDE OF DEADWATER VALLEY, CORRELATED WITH THE DEADWATER SECTION.

	Feet.
Cretaceous sand to top of hill.	
Sandstone, dark gray, cliff-making (No. 2)	6
Sandstone, thin-bedded, thick-bedded at the base (part of No. 3)	8
Concealed	10
Sandstone, thin-bedded, shaly	5
Massive, gray to greenish, cliff-making sandstone ledge (No. 4)	6
Shale, light yellow, clayey	5
Concealed (horizon of sandstone No. 8)	18
Shale, brown, massive, blocky, sandy	5
Concealed	8
Shale, brown, clayey, soft, changed to dark brown at bottom	18
Concealed to creek shale and sand debris	25
Total	114

At this place the position of the coal of the Deadwater section is probably at. or just below, the creek.

On Deadwater Creek, south of the Fayette-Bankston road, no good exposures occur for half a mile. Within this distance the rocks change from a downstream to an upstream dip. sandstone Nos. 8 and 4 of the Deadwater section again appear on the hillsides in low cliffs of compact thin-bedded greenish sandstone containing one or more massive layers. At a few places along the creek occur small exposures of the dark brown to bluish shale and thin-interbedded sandstones which occupy the position of No. 9 of the Deadwater section. At one locality the entire interval between sandstones 4 and 8 is occupied by light brown, very sandy shale containing a few thin layers of sandstone. All of the sandstones of the

Deadwater section decrease in thickness southward along this valley and no good exposures are present on the west side south of Bankston. On the east side of the valley what appears to be sandstone No. 4 is well exposed in the road about ¼ mile northeast of the station at Bankston. On the hillside east of the road at this point a massive ledge of sandstone (probably No. 2) protrudes through the Cretaceous sand. The following section shows the rapid change in the sandstones of both the Clear Creek and the Deadwater sections southward from the type localities:

SECTION ON "BYLER ROAD" EAST FROM BANKSTON.

		Feet
(1)	Reddish, sandy debris, probably concealing beds of badly weathered sandstone and reddish sandy shale for 25 feet below top of hill.	
(2)	Sandstone and shale, thin-bedded, badly weathered, reddish and greenish	13
(3)	Sandstone, thin-bedded, brownish with 1 or 2 somewhat massive layers (lower part probably horizon of sandstone No. 2 of the Deadwater section and sandstone No. 6 of the Clear Creek section)	14
(4)	Shale, grayish to greenish, very sandy	8
	Concealed (reddish, shaly, and thin-bedded sandstone debris)	35
(5)	Sandstone, greenish, thin-bedded, pronounced joint planes (probably No. 8)	5
(6)	Shale, brown, blocky, somewhat massive with thin beds of sandstone	20
	Total	95

Along the hillside south of this exposure the somewhat prominent sandstone (No. 3 of this section) is exposed as a low cliff at a number of places where one or two layers of it become massive. It here resembles very closely sandstone No. 2 of the Deadwater section. The beds rise southward to the point of the hill at the railway cut and either sandstone No. 2 or No. 8 is exposed at almost all points throughout this distance.

A small tributary enters Deadwater Creek at its junction with Baker Creek, about one-third mile north of Bankston. Along this small stream the rocks show a relatively rapid dip upstream. Just below the forks in the stream, about ½ mile from its mouth, sandstone No. 8 of the Deadwater section is

exposed on the hillside about 40 feet above; whereas at the forks this sandstone is only about 12 feet above the stream. Between this point and the mouth of the stream the horizon of the coal of the Deadwater section comes to the surface, but no coal could be found. About 20 feet below sandstone No. 8, at the fork of the small stream, a peculiar irregularly-bedded, somewhat massive, greenish, shaly sandstone is exposed in two layers, each about 3 feet thick and separated by about 4 feet of dark brown blocky shale. This sandstone seems to be just above the coal of the Deadwater section. It is very irregular in occurrence but thickens and becomes more sandy toward the southwest.

Farther up the stream sandstone No. 2 of the above section is present in a typical, cliff-making exposure, and below it sandstone No. 6 is represented by a thin bed of compact, cliff-making, greenish sandstone, 6 feet in thickness. Near the head of the south fork of this stream a massive yellowish, badly weathered sandstone protrudes from the Cretaceous sand a few feet above the stream. There is no way of determining the stratigraphic position of this bed which will be referred to as sandstone 1b. The rocks are concealed between this exposure and the nearest one of sandstone No. 2, about 1,100 feet downstream, and the dip between these two exposures is therefore uncertain. If the dip is uniform the horizon of this sandstone is between 75 and 100 feet above sandstone No. 2, and hence between 140 and 180 feet above the coal of the Deadwater section. At the exposure of this sandstone the dip appears to be somewhat less than at the last exposure of sandstone No. 2 on this stream, and the interval between these sandstones is estimated to be approximately 65 feet.

The first recognizable exposures up Baker Creek occur about 1 mile from its mouth. Here a massive cliff-making sandstone, believed to be No. 8 of the Deadwater section outcrops on both sides of the valley and may be traced along the east fork of this creek almost to the Woods deep well No. 1 (B) where it goes below drainage under Cretaceous cover, with a relatively rapid dip upstream.

Along the west fork of this creek sandstone No. 8 dips rapidly westward, passing below the valley within 1,500 feet, at a point where sandstone No. 4 of the Deadwater section appears below the Cretaceous cap on the hillside south of this

stream. This sandstone is at creek level less than 1,000 feet farther north, and about 800 feet still farther upstream sandstone No. 1 b, described as above as being about 65 feet above sandstone No. 2, is exposed on the north side of the valley, about 60 feet above the stream. This sandstone is about 10 feet thick, very massive, yellowish, and deeply weathered. It very probably was a resistant bed near the tops of the ancient pre-Cretaceous hills, and doubtless materially affected the topograhy of that old land surface. The other exposures of shale and sandstones serve to make more positive the correlation of the sandstones.

On the north side of Little Pinney Creek, in the southeastern part of the N. E. ¼ of S. E. ¼, Sec. 16, T. 16 S., R. 11 W., the following is exposed:

SECTION EXPOSED ON LITTLE PINNEY CREEK.

		Feet
(1)	Cretaceous sand	
(2)	Sandstone, massive, cliff-making, grayish to greenish	3
(3)	Sandstone, thin-bedded, shaly, greenish	8
(4)	Sandstone, massive, cliff-making, grayish	3
(5)	Sandstone, thin-bedded, very shaly	4
(6)	Sandstone, massive, cliff-making, grayish	3
(7)	Shale, yellowish brown, sandy, blocky, 7 feet exposed at top with 6 feet at bottom concealed by shale debris	13
(8)	Sandstone, massive, gray, cliff-making	4
(9)	Concealed by sandstone and shale debris	19
(9b)	Sandstone, very irregular, bedded, shaly, brown to greenish sandstone below	4
(10)	Shale, dark bluish to brown, sandy, concretionary (to creek level)	10
	Total	71

The numbers given in the above section correspond to those of the Deadwater section with the addition of sandstone 9b, which comes into the section west and south of Bankston. Though the members 2 to 6 inclusive form a single sandstone 21 feet in thickness, the cliff-making strata within it appear to correspond closely to those of the Clear Creek and Deadwater sections, but if these do not belong to exactly the same horizons, the three sections are certainly of the same sandstone. The bluish brown shale (No. 10) at the base of the above section is the same shale as that of above mentioned sections, and the horizon of the coal of those sections is only a few

feet, at most, below creek level. Sandstone No. 2 of this section appears to be only about 72 feet above the coal horizon here as against 83 feet in the Deadwater section, though the distance between the other beds and this coal appears to be practically the same, the entire variation being between sandstones Nos. 2 and 4. The cliff-making sandstone of the Deadwater section is traceable as ledges along the sides of the valleys of Little Pinney Creek and its tributaries below the outcrop described above, and spirit level lines were run to them at a number of places. The most westerly exposure of one of these beds is on a small tributary of Little Pinney Creek in the S. E. ¼, S. W. ¼ of the S. E. ¼ Sec. 16. Here a massive, brownish green sandstone a few inches thick protrudes from the Cretaceous cover, at a small waterfall in the stream. Its identification is very uncertain, but it most probably is the ledge called sandstone No. 4 in the Deadwater section.

On the north fork of Little Pinney Creek in the N. W. ¼ of the S. W. ¼ Sec. 15, T. 16 S., R. 11 W., a massive sandstone which appears to be No. 8 of the Deadwater section outcrops in the point of a hill just west of a house and north of the public road. This bed dips northeast and is exposed at two or more places on the stream for a short distance. Farther up this stream sandstone No. 2 is exposed and at the road crossing still higher up a massive, deeply weathered yellowish sandstone is exposed in contact with the Cretaceous sand a few feet above stream level. The identification of this bed is uncertain but it evidently is one of the upper sandstones exposed in this vicinity.

In the central part of Sec. 15, T. 16 S., R. 11 W., sandstone No. 8 of the Deadwater section is exposed as a narrow cliff on both sides of the valley of Little Pinney Creek at 40 to 60 feet above the stream. At places sandstone No. 9 b is also exposed as a greenish shaly, fossiliferous sandstone. This sandstone is exposed on the "Byler Road" in the extreme northeast corner of Sec. 22, and above it sandstone No. 8 is in typical outcrop. About 1.500 feet farther south on this road, a massive, deeply decayed sandstone is exposed, a portion of which is probably No. 2. The outcrops of these sandstones were traced along the south fork of Little Pinney Creek almost across the northern part of Sec. 22. The cliff-making beds along this creek are sandstones Nos. 4 and 6 of the

Deadwater section, both of which are at places quite massive. In the northern part of the S. E. ¼ of the N. W. ¼ of Sec. 22, a coal bed is said to occur in the bottom of the creek. The writer did not see its outcrop, but since the horizon of the coal of the Deadwater section is at about this level, it is possible that a coal is present there. If so, it is the only place where this coal bed is known to occur south of Bankston in the area mapped.

Portions of sandstones Nos. 2 to 6 of the Deadwater section are exposed along the "Byler Road" from Little Pinney Creek southward to Rock Creek above Dardon's Mill. About ¼ mile west of this mill a fine exposure of the sandstones of the Deadwater section occurs on the abandoned road just above where the "Byler Road" crosses Rock Creek, at which place the following section was noted:

SECTION ON ABANDONED ROAD ON WEST SIDE OF THE "BYLER ROAD," ONE-FOURTH MILE WEST OF DARDON'S MILL.

		Feet
(1)	Shale, reddish, sandy, deeply weathered, at top of hill	5
(2)	Sandstone, coarse, reddish, deeply weathered	5
(3)	Shale, sandy, whitish, deeply weathered, with pronounced vertical joints producing long rectangular blocks, with streaks of whitish clay	6
(4)	Sandstone and shale, massive, greenish beds at top, 3 feet thick, very deeply weathered, with 2 feet of light colored shale, then 2 feet of thin-bedded, greenish sandstone, then 4 feet of massive cliff-making greenish sandstone at base	11
(5)	Sandstone, greenish, thin-bedded, shaly	5
(6)	Sandstone, very massive, cliff-making, irregular bedded	5
(7)	Clay, shale, and sandstone, 3 feet of bluish, very sandy, very fossiliferous, clay and shale, with 1 foot of thin-bedded, greenish shaly sandstone below	4
(8)	Sandstone, thin-bedded, compact, cliff-making, ripple-marked, greenish	6
(9)	Shale, coarse, very sandy; bluish, brown, blocky to creek level	3
	Total	50

The numbers in the above section conform to those of the Deadwater section. The 3 feet of bluish fossiliferous clay of No. 7 appear to be the horizon of the coal mentioned above as being exposed in the S. W. ¼, Sec. 34, T. 15 S., R. 11 W., northeast of the locality of the Deadwater section. Many carbonized fragments of plants were seen in it.

One or more of the cliff-making beds of the Deadwater section are exposed along Rock Creek in Sec. 27, T. 16 S., R. 11 W. Sandstone No. 8, usually thin bedded, outcrops near creek level. Sandstones Nos. 4 and 6 are very massive in the central part of Sec. 27, and from this place to the point where they disappear abruptly below drainage in the S. E. ¼, N. W. ¼ of the section. It is believed that a fault crosses the creek at this point in nearly a north-south direction with the downthrow on the east side. A few yards above the place where the sandstones disappear in the creek bed with a sharp dip to the northwest, a thick, bluish brown, blocky shale, very similar to No. 9 of the section described above is exposed in the creek bank. Up the creek from this point only occasional thin beds of sandstone occur in the shales, the beds appearing to dip slightly to the southwest.

Exposures of Pottsville rocks on North River and small tributaries.—The area discussed under this heading lies in Secs. 23 and 26 in the extreme southeastern portion of the area mapped. At Dardon's Mill on North River, the exposed beds appear to consist of sandstones Nos. 4 to 8 inclusive, of the Deadwater section. Some of these cliff-making beds are seen along the river bluff for half a mile downstream, but because of scanty exposures none of them could be positively identified. About ¼ mile upstream the river washes the base of a high bluff on the north side in which the above named sandstones are exposed in a typical outcrop. Here beds Nos. 4, 6, and 8 are cliff-making. Bed No. 2 appears to have been eroded at this point, but on the hillside about ¼ mile northwest of this locality, it is exposed in continuous outcrop for half a mile.

A tributary enters North River a short distance above the bluff, along which occur numerous exposures of beds Nos. 4 and 6 and about ¾ of a mile from its mouth bed No. 2 goes below water level in contact with Cretaceous sand.

Exposures of Pottsville rocks on Davis Creek.—West of the outcrops in Secs. 16, 22, and 27, T. 16 S., R. 11 W., described above, no exposures of Carboniferous strata occur within the area mapped except at a few localities along Davis Creek below Fortenberry's Mill. At this place the following section is exposed:

SECTION ON DAVIS CREEK NEAR FORTENBERRY'S MILL.

		Feet
(1)	Cretaceous sand and conglomerate	
(2)	Reddish shale and thin-bedded sandstone, so deeply weathered as to be hardly distinguishable from the overlying unconsolidated sand	5
(3)	Sandstone, massive, reddish to light, very deeply weathered	5
(4)	Sandstone, massive, cliff-making, greenish	4
(5)	Sandstone, thin-bedded, greenish, shaly	5
(6)	Clay, bluish, sandy, containing carbonized fossil plants	3
(7)	Sandstone, somewhat massive, smooth-bedded, to water in creek below dam	6
	Total	28

In this section sandstones Nos. 4 and 7 may be equivalent to Nos. 6 and 8, respectively, of the Deadwater section. The 3 feet of clay appears to be the same as that described above as No. 7 of the section on Rock Creek. This correlation is supported by the statement of Mr. Fortenberry that a small coal had once been found a short distance above his mill at a point which appears to be at about this horizon.

By the roadside about ¼ mile south of Fortenberry's Mill a small exposure of massive, greenish sandstone, projecting from the Cretaceous sand, is tentatively considered to be bed No. 6 of the Deadwater section. No other exposure of Carboniferous beds was found on Davis Creek, except in the vicinity of White's Mill. Under this mill about 14 feet of massive greenish sandstone extends from the water below the dam up to road level. Above this is exposed about 4 feet of thin-bedded, greenish sandstone overlain by about 2 feet of somewhat massive sandstone up to the Cretaceous. About 200 yards east of the mill a small exposure of massive sandstone seems to be the upper part of the sandstone under the mill. There are no data at hand upon which to base a safe correlation of the sandstone exposure at White's Mill with those at Fortenberry's Mill. The former seems likely to be at least a portion of the sandstone of the Deadwater section. If this correlation is correct, the top of the massive bed under White's Mill is probably at or near the horizon of the cliff-making bed shown in the Deadwater section as No. 4. In the absence of positive data on this point, the above correlation is used in attempting to show the structure of the rocks along Davis Creek.

Exposures of Pottsville rocks on Box's Creek and tributaries. —Pottsville rocks are exposed along Box's Creek and its tributaries in Sects. 30 and 31, T. 15 S., R. 11 W.; in Sects. 35 and 36, T. 15 S., R. 12 W., and in Sects. 1, 2, 3, 9, 10, 11, 12, T. 16 S., R. 12 W. These outcrops consist of sandstone, sandy shale, and a single exposure of coal. The coal is exposed in a shallow pit in the valley near the N. E. corner of S. W. ¼ of the S. W. ¼ Sec. 1, T. 16 S., R. 12 W. No measurement of the coal could be secured, but it appears to be less than 18 inches thick. It is overlain by about 5 feet of reddish brown shale above which is 8 or 10 feet of sandstone near the top of which occur massive cliff-making layers. This sandstone appears to be No. 6 of the Deadwater section, what appears to be sandstone No. 4 of this section being exposed in typical outcrop above. The coal seems to be the same as that exposed on the western edge of the N. E. ¼, N. W. ¼, Sec. 34, T. 15 S., R. 11 W., and is probably 41 feet above the coal of the Deadwater section.

Southeast from this coal outcrop sandstones Nos. 4 and 6 of the Deadwater section are exposed in continuous outcrop to the forks of the stream, but beyond that point they lose their cliff-making character and exposures of them are poor. They seem to grade into sandy shale with thin layers of smooth-bedded sandstone. On the east fork of this little stream, in the southern part of Sec. 1 and the northern part of Sec. 2, a few outcrops of thin sandstone and a number of exposures of shale occur. On the west fork, sandstone No. 6 goes below drainage a short distance above the forks and exposures of sandy brown shale only and a few thin sandstones were seen on the stream above that point.

From a place northwest of the exposures of the coal bed, sandstones Nos. 4 and 6 of the Deadwater section are finely exhibited on the north side of the valley to its mouth. In a small stream a short distance north of this point sandstone No. 8, which underlies the coal bed, is well exposed as a very massive irregularly bedded greenish sandstone. This bed forms the low bluff along the western border of Sec. 2, and from this place northward to the railroad bridge over Box's Creek, where it is exposed on the south side a few feet above the railroad. At this place a large tributary enters Box's Creek from the north, up which scattered exposures of Potts-

ville beds occur for about 1½ miles. Sandstones Nos. 4 and 6 form low cliffs on the east side of this valley for about one mile, and sandstone No. 8 passes below drainage near the crossing of the Bankston-Fayette road. Near the eastern edge of the S. W. ¼, S. E. ¼, Sec. 35, T. 15 S., R. 12 W., sandstone No. 6 is exposed at the top of the creek bluff, and below it is about 9 feet of dark bluish brown, fissile, clayey shale which probably marks the horizon of the coal described above. Half a mile farther north a massive, medium-grained layer of sandstone 5 feet thick has been quarried at two places a few feet above the stream. This bed was not clearly identified but it seems to be either sandstone No. 4 or No. 6 of the Deadwater section. It is exposed in the road opposite a house about ⅛ mile farther north, where it dips at a high angle to the northeast. On the east side of the valley this sandstone is again exposed with a N-N. E. dip of probably 60 or 70 degrees. These exposures are too small to be of much structural value. They probably mark a slight fault or sharp buckle in the surface beds.

Small exposures of shale and thin interbedded sandstone occur along this valley to the southern edge of Sec. 25, but above that point the Pottsville rocks are concealed by Cretaceous sand.

Along the railroad through the northern part of Sec. 1 the cliff-making beds Nos. 4 and 6 are almost continuously exposed. They are here thin-bedded, compact, greenish, shaley sandstones with occasional thicker layers of purer sandstone. North of Stough, in the S. E. ¼, Sec. 36 and the western part of Sec. 31, the sandstones are generally thin-bedded and poorly exposed, but they have been quarried in a small way at one or two places. These quarries appear to be on sandstone No. 4 of the Deadwater section. Northward through Sec. 31 and as far as the center of Sec. 30 sandstone is well exposed at many places along the sides of the valley. In the latter locality, where the Pottsville rocks disappear beneath the Cretaceous sand, a massive yellowish sandstone having much the appearance of No. 8 of the Deadwater section is exposed in the bank of the creek, above a few feet of dark bluish-brown shale. This may be, however, a locally massive phase of sandstone No. 6. A close correlation of the sandstone ledges along this creek is very difficult because of their variability.

Sandstone and shale are exposed on both sides of Box's Valley, through Sec. 2, T. 16 S., R. 12 W., from the coal outcrop described above, and on the south side of the valley in the northern part of Sec. 11. The writer is not certain of the identification of the massive sandstone ledge at the top of the cliff on the south side of Box's Creek in the southeastern part of Sec. 2. It is either sandstone No. 4 or No. 2 of the Deadwater section. It seems more probably a local thickening of No. 2. The sandstone exposed at the above locality is more or less massive to a short distance south of Sec. 2 where it changes within 150 yards to yellowish brown sandy shale and thin smooth-bedded sandstone, and farther along this outcrop in the N. E. ¼, Sec. 11, the sandstone bed known as No. 4 of the Deadwater section is quarried at a number of places. This group of cliff-making sandstone beds is exposed in the road at the foot of the hill in the southern part of Sec. 2. Sandstone No. 2 also disappears below Cretaceous wash in the N. W. ¼, S. W. ¼, S. W. ¼, Sec. 2, but it has been quarried a short distance to the west of this place. Between this outcrop and Gas Wells Station no outcrops of Pottsville beds were seen on the north side of Box's Creek. On the south side of the valley these beds are concealed by the Cretaceous to about ¼ mile west of Sipsey Station, where a small exposure of shale with some shaly interbedded sandstone occurs along the creek bank for about ¼ mile. A similar exposure of shale occurs on the west side of the tributary to Box's Creek from the south which enters Sec. 9 at the southeast corner. This exposure extends more than half way across the southern portion of Sec. 9 from the southwest corner and consists of a few feet of brown to greenish sandy shale and thin layers of sandstone, except near the western end where 10 feet of massive greenish irregular-bedded sandstone is exposed in the creek bluff. This sandstone is also exposed on the opposite side of the valley at Gas Wells Station. These exposures are such as to leave doubt as to the proper correlation of this sandstone with the beds described above. In general appearance it resembles both sandstone No. 8 and sandstone No. 2 of the Deadwater section, but from the general dip shown by the exposures along Box's Creek in Sects. 9 and 10 the writer thinks that it is most likely the latter. He is fully aware that such a correlation is extremely hazardous when based solely on a hurried examination of the

exposures found between this place and the type locality of the Deadwater section, and he therefore in no sense considers such a correlation final until it is supported by a more thorough field examination and by sufficient paleontological data to clearly establish the age of these beds.

If the above correlation proves to be correct, the 90 feet of sandstone and sandy shale found below the alluvium in Providence well No. 1 (Well section G, Pl. II in pocket) is the prominent sandstone described above as containing the cliff-making beds 2 to 8, inclusive, of the Deadwater section. The coal bed which is reported in the shale overlying this sandstone in Providence well No. 6 (section H, Pl. II in pocket) correlated above with the Brookwood Coal, is probably equivalent to the coal described as outcropping in the spring in the central part of the N. E. ¼, S. E. ¼, Sec. 28, T. 15 S., R. 11 W..

Exposures of Pottsville rocks along Sipsey River.—Along Sipsey Valley within the area mapped the exposures of Pottsville beds are confined to a small outcrop of sandstone and shale in the road ¼ mile north of Gas Wells Station. A small outcrop of massive sandstone with some shale is shown in the river bluff at and for about one-third of a mile south of Newton's Mill; and a similar exposure appears along the river bluff farther north in Sects. 28 and 33. The sandstone seen in the road north of Gas Wells Station is the same as that in the railroad cut at this place. At Newton's Mill twenty feet of massive sandstone outcrops above river level. The upper part of this bed is a coarse light to yellowish massive sandstone which appears to be the same as that at Gas Wells. A fault with a general northwest-southeast trend is shown at this mill, but north of it for almost a mile the Pottsville rocks are not exposed.

At a place where Sipsey River washes the base of the hills about ¾ mile north of Newton's Mill, alternating layers of brown sandy shale and thin shaly sandstone are exposed which have a slight dip upstream. From this place northward along the base of the hills similar beds are sparingly exposed. At the point where the line between Sects. 28 and 33 cuts the base of the hills, a massive cliff-making sandstone is well exposed showing a fault, striking about N. 45° W., with the downthrow to the southwest, the displacement being 40

feet or less. This appears to be sandstone No. 2 of the Deadwater section. Northward from this place the sandstone dips gently upstream and soon disappears below valley level.

Exposures of Cretaceous and Younger Beds in the Fayette District.

As the object of this examination was to determine the conditions under which gas has accumulated in the Carboniferous rocks, little attention was given to the Cretaceous and younger beds which overlie the gas-bearing formation unconformably, and which are of no value in attempts to determine the dip of the gas-bearing beds. On the map the exposed areas of Cretaceous and Tertiary beds are shown by the green tint. These rocks are composed of unconsolidated sand and clay with some beds of dark red conglomerate and coarse red sandstone cemented by iron. The valleys are covered by superficial beds of wash and alluvium of Recent age, deposited by the present streams.

STRUCTURE.

General Structure of the Region Surrounding the Fayette Gas Field.

The general structure of the Warrior coal basin, in which the Fayette gas field occurs, is that of a broad, flat basin, gently tipped to the southwest, with the strata steeply upturned and faulted at the eastern edge along Birmingham and Sequatchie valleys and the western limb hidden beneath the unconformable Cretaceous beds. The most prominent structural feature in this basin is the Sequatchie anticline (Pl. I). This fold is highest at the northeast border in Blount County, and pitches southwest to the northern part of Tuscaloosa County, where it flattens out and loses its prominence. Between this anticline and Birmingham Valley the rocks though generally synclinal in structure are wrinkled into many minor folds and in places are cut by many faults.

West of Sequatchie anticline the rocks are less disturbed and no large, well-defined folds have been discovered, though the area seems to have been subjected to enough deformation

to slightly wrinkle the strata into many low irregular folds and in some places to produce local faults of slight displacement. The structure of the Warrior basin has not been studied in sufficient detail so that the positions of all minor folds have not been traced out and mapped.

On Plate I the general structure of the basin is suggested by the lines marking the outcrops between the formations noted thereon. The direction of the line of contact between the Pennsylvanian and Mississippian rocks shown on the map from the western border of the State is almost due east to the southeastern part of Morgan County, from which it bends sharply to the northeast to Tennessee River. This line is seen to be roughly parallel to the outcrop of the Bangor limestone which marks the northern edge of that part of the Mississippian series shown on the map. This change in direction of the line of outcrop seems to be due to a broad doming of the strata north of Tennessee River along a line passing near the towns of Athens and Decatur from which a broad anticline trends along southward through the western part of Morgan and the eastern part of Winston counties. The effect of this fold is noted in the curve in the outcrop of the Black Creek coal bed in northern Walker County, as shown by the dotted line on Plate I. The direction of the line of outcrop of this coal is northeast to the bottom of the syncline west of the Sequatchie anticline; thence southward along the western limb of this fold crossing the axis near Quinton in the northwestern part of Jefferson County, from which it bends again toward the northeast to the axis of the syncline on the east side of the Sequatchie anticline, from which it again trends in a southern direction to the edge of Birmingham Valley north of that city. There is evidently a well-defined synclinal area a short distance west of and parallel to the Sequatchie anticline throughout its entire length, but the details of the structural features in and west of this area are not known, except in a portion of the Fayette district which is described below.

The folds in the Warrior field which have a general northeast-southwest trend were formed during a period of great crustal movements when very intense folding and large thrust faults were produced along the Appalachian Mountains from middle Alabama to the State of New York. In Alabama this belt of intense folding and faulting lies east of the Warrior

coal field. The impulse which produced this deformation came from the southeast and most of its energy was expended before reaching the Warrior field. The Sequatchie anticline is the most northwestern fold of prominence that was developed by this movement. Westward from it strata originally horizontal were more or less wrinkled into a series of broad, open, irregular folds, having a general northeast-southwest trend.

Another period of deformation in portions of the Warrior coal field was marked by the depression of the region to the west of it along an axis parallel to the present course of Mississippi River below its juncture with the Ohio. This sinking was followed by an encroachment of the sea in which the Cretaceous and Tertiary sediments were laid down. This regional depression may have produced more or less deformation in the Warrior field, the folds having a general northwest-southeast trend. These two great crustal movements are responsible for the structural features in the Fayette district.

STRUCTURE OF THE CARBONIFEROUS ROCKS OF THE FAYETTE DISTRICT.

GENERAL STATEMENT.

On the map (in pocket) an attempt has been made to show the dip of the Carboniferous strata in portions of the Fayette district by the use of the contour lines printed in brown. These contours are lines of equal level with a vertical interval of 10 feet and are numbered according to their height in feet above sea level. They are drawn upon the horizon of the coal bed described in the Clear Creek and Deadwater sections in the chapter on "Areal distribution and character of outcropping beds." For example, the heavy brown contour line marked 350 is drawn through all points supposed to be on the horizon of this coal bed that are 350 feet above sea; the next brown line on one side of it marks all points on this coal that are 340 feet above sea, and the one on the opposite side marks the points at which the coal is 360 feet above sea level.

Accuracy of the structural contours.—The accuracy with which structural contours may be drawn upon any deformed surface depends, of course, upon the number and position of the points at surface whose actual elevation above sea level has

been determined by instrumental work in the field; and this in turn depends upon the position and extent of the outcrop of the bed upon which the measurements are taken. Unfortunately, in the Fayette district the coal bed upon which the structural contours are based is exposed at not more than four places, so far as the writer is aware. In order partially to avoid the difficulties of contouring a bed which is so rarely exposed, the writer has used the approximate vertical distance between this bed and the tops of the cliff-making sandstone beds described in the chapter on "Areal distribution and character of the outcropping rock," and used these vertical distances to calculate the height of the horizon of the coal at places where it is not exposed or could not be found. In this way all of the measurements secured upon recognized beds were reduced to approximate elevations of the coal bed and from these elevations and the known dip of the exposed beds, the contours were drawn.

By the method just described it will be seen that the structure or 'lay" of any bed that is well exposed can be determined very accurately. From these facts and the data set forth in the chapter on "Areal distribution and character of the outcropping rocks" the reader can readily see that though the contours on the map in the main show the structure fairly accurately, they may be considerably in error locally because of the lack of accurate measurements on the key surface.

In places on the map where no contours are drawn, the surface is covered by Cretaceous and younger beds which prevent accurate measurements on the coal. The structure of the Carboniferous rocks in this part of the district is unknown and cannot be determined accurately until a sufficient number of wells have been drilled which will furnish accurate measurements to some recognizable bed. This statement applies equally well to any part of the Gulf Coastal Plain in Alabama, where the Carboniferous beds are concealed beneath Cretaceous and younger sediments.

In places where the structure contours are solid lines positive elevations obtained on recognizable beds are sufficiently numerous to warrant the assumption that they are approximately correct. The broken contours while based upon some accurate data may be in considerable error. The accuracy of those contours that bear interrogation marks is in doubt. Care

should be taken in using these contours to give due allowance for errors that are likely to creep into work based on insufficient data or on data not known to be accurate.

Structural Features in the Carboniferous Strata.

The structural contours on the map show clearly that the deformation in the Carboniferous beds of this particular area has been relatively slight, and that the beds lie in broad, open, irregular folds, having a trend generally northwest, southeast in the eastern part of the mapped area and probably a more east-west trend farther west.

The principal structural features, partially brought out by the contours on the east side of the map, are the belts of relatively rapid southwest dip. One of these belts passes through the eastern parts of secs. 28 and 33 and the western parts of Sects. 27 and 34, T. 15 S., R. 11 W., and continues southeastward through Sects. 3, 2, and 11, T. 15 S., R. 11 W. Southwest of this belt of relatively steep dip is a shallow syncline, the bottom of which passes through the central part of Sects. 29 and 33, T. 15 S., R. 11 W., and Sects. 3, 10, 14, 15, and 23, T. 16 S., R. 11 W. Southwest of this trough the rocks appear to rise gently to the axis of a very low broad anticline which appears to pass through Sects. 3, 29, and 32, T. 15 S., R. 11 W., and Sects. 4, 10, 15, 22 and 27, T. 16 S., R. 11 W.

Southwest of this anticline the Cretaceous sand obscures the structure and it cannot be determined with any degree of certainty except in portions of Secs. 4, 9, 10, 15 and 16, T. 16 S., R. 11 W., where the steep dip of the rocks discloses what appears to be the eastern end of a syncline of considerable magnitude, pitching west-northwest under the Cretaceous beds. The lowest portion of this trough probably has not been contoured, but in the southeast corner of Sec. 9, the key surface is at least 200 feet lower than it is in the central part of Sec. 35, T. 16 S., R. 11 W. There may be faults in this area which render the observed dips misleading, but no direct evidence of a fault was seen in the field.

On Box's Creek no well defined fold is revealed by the structure contours in the area of Carboniferous rocks exposed. The very gentle dip toward the south and southwest

appears to be interrupted by a shallow syncline passing through Secs. 1 and 2, T. 16 S., R. 12 W., and by another small syncline, the beginning of which is shown at the southeast corner of Sec. 35.

Local buckles (small anticlines).— In the southwest part of Sec. 1, T. 16 S., R. 12 W., there is evidence of a small anticline, of a very small extent, which brings the exposed Pottsville sandstones up into a very sharp fold, having a general northeast-southwest trend, with dips of 40 to 80 degrees, but with a total width of only a few feet. This type of structure is apparently very common to this region. On the road in the southern part of the NE ¼, NE ¼, Sec. 11, T. 16 S., R. 12 W., a similar buckle brings the Pottsville sandstone up at an angle of 50° to 70°. Two other buckles of only a few feet in width are finely exposed on the Fayette-Bankston road in the N. E. ¼, N. W. ¼, Sec. 1, T. 16 S., R. 12 W. These appear to have a northwest-southeast trend. Another of these local buckles occurs on the road near the western edge of the N. W. ¼, N. W. ¼, Sec. 36, T. 15 S., R. 12 W. Others of less magnitude were seen, but as these miniature anticlines were probably formed by local compression due to the subsequent wrinkling of slightly folded beds across the major folds they are probably very local features that extend only to shallow depths.

Faults.—Few faults occur in the area mapped and these appear to be confined entirely to breaks in the strata due to tension. They seem to be very local in extent and to show small vertical displacements. One of these faults is exposed on the road leading southeast from Cotton's Mill in the N. E. ¼, S. E. ¼, Sec. 33, T. 15 S., R. 11 W. Here the downthrow appears to be to the north and the displacement is probably between 40 and 50 feet. The trend of this fault seems to be northwest-southeast.

Another fault is thought to occur on Rock Creek about ¼ mile west of the road crossing in Sec. 27, T. 16 S., R. 11 W. Here the Pottsville sandstones suddenly disappear and are succeeded upstream by dark bluish-brown, sandy shale, which resembles closely beds of shale lying from 40 to 80 feet below the sandstone. If these identifications are correct the fault has an almost north-south trend with the downthrow to the east.

At Newton's Mill in the southern part of Sec. 33, a well marked fault occurs with a general northwest-southeast trend. However, the lack of good exposures at this place leaves the writer somewhat in doubt as to the character of this fault. It may either have a displacement of 70 or 80 feet with the downthrow to the southwest or the downthrow may be to the northeast with 20 or 30 feet displacement.

One mile north of Newton's Mill, near the northeast corner of Sec. 33, a fault is exposed in the bluff at the foot of the river hill. This fault has a displacement of less than 40 feet, the downthrow being to the southwest.

In the core drill hole of the Cosmos Oil and Gas Company (Section E, Plate II in pocket) the black shale No. 16 shows many slickensided surfaces which suggest faulting, but other evidence of a fault at this place is obscured by wash of Cretaceous debris which hides the Carboniferous rocks.

The faults in the Fayette district are probably due to differential tension developed locally by the subsequent wrinkling of slightly folded strata almost at right angles to the folds. This subsequent wrinkling was apparently so slight that faults of very local extent only could have been developed. The depths to which displacements of strata extend along these fault is, of course, unknown. However, because of the slight amount of folding, the local nature of the tension thus developed, and the predominance of soft yielding shale below the surface, it seems reasonable to assume that the depths to which the displacement may extend is relatively very small.

Structure of the Fayette gas field.—The available data relative to the structure of the Fayette gas sand in and surrounding the gas field, are too meager to justify an attempt to draw structure contours on this bed. Therefore, instead of contours to show the structure of the sand, the altitude of the mouths of the wells and the depths to the gas sand in each are shown on Plate II. From these figures the depth of the gas-bearing sand below sea level can be easily calculated.

No records of wells Nos. N, P, R, S, T, and U were obtained, and the Fayette gas sand is not shown in well sections C and D. In all of these wells a sandstone near the top has been correlated with the massive sandstone which is exposed at Newton's Mill, at Gas Wells Station, and on the south side

of Box's Creek southeast of this station. As already stated, this sandstone is believed to be the upper sandstone No. 2 of the Deadwater section which is exposed up Box's Creek' and in the eastern part of the area mapped. Altitudes obtained on this bed have been reduced to equivalent ones on the coal used as a key stratum, and contours drawn to show the approximate dip of the key rock in the gas field, in order to give some idea of the structure. These contours are printed on the map in brown. With these few facts as a basis for deductions Figures 1 and 2 were drawn as mere guesses at what the structure may be found to be when future drilling has furnished sufficient data to enable the contours to be drawn accurately. In addition to these two figures the imagination of the reader can supply many different ones which may be drawn without contradicting any of the facts, now known, regarding the dip of the beds in this vicinity.

In figure 1 the position of the Fayette gas field is assumed to be on the west side of a pitching anticline having a general north-northeast-south-southwest trend. The flat-topped crest of this fold occupies the eastern part of Sec. 9 and the western third of Sec. 10, from which the rocks rise northward along the axis of this fold. In this sketch the position of the fold is based upon the negative fact that there is nothing available to show that the sandstone outcropping at Newton's Mill and dipping southward does not have a continuous dip from that point to its next exposure on the road near well E; and that the sandstone found near the top of well D is the same bed. In drawing these contours the assumption is made that a shallow syncline crosses Box's Valley from north to south in the vicinity of Sipsey Station, and that to this trough is due the fact that here are found no exposures of the sandstones which outcrop farther up the valley. The apparently slight dip of the beds down stream in the S. E. ¼, Sec. 9 suggests that the axis of this fold may trend almost north and south in the western part of Sec. 10. The syncline shown as passing southwestward through Sections 4 and 8 is assumed to exist because the apparently steep dip between wells L and K suggests that the strike of the beds is at right angles to the line connecting these wells; and that if this is true the contours must make a sharp bend in passing northward from the gas field. The contours in the gas field proper

GEOLOGICAL SURVEY OF ALABAMA FIG. 1 BULLETIN No. 10.

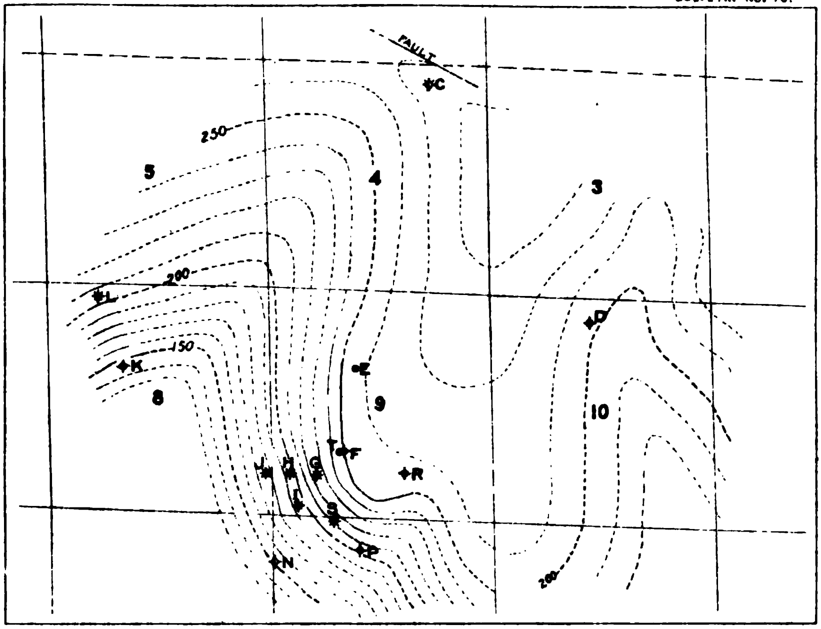
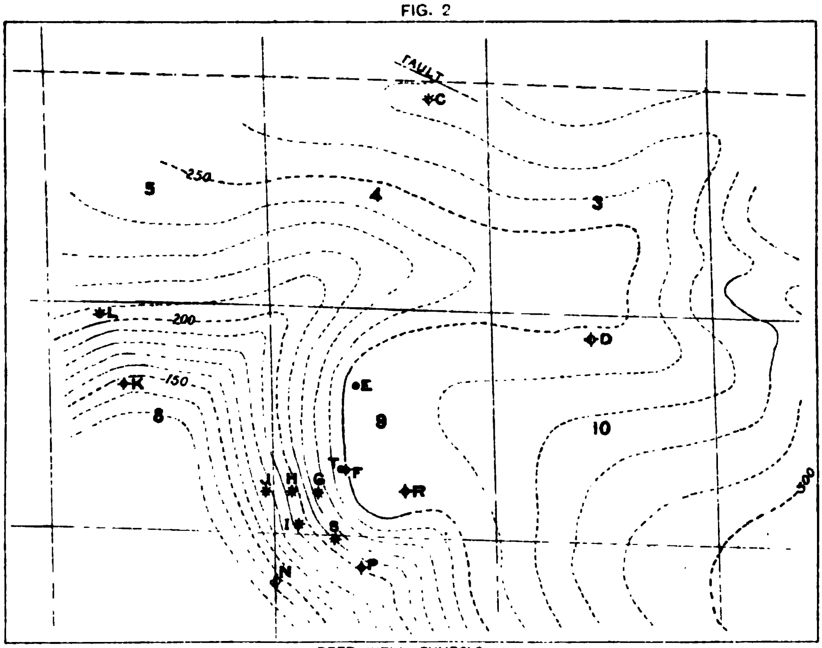


FIG. 2



DEEP WELL SYMBOLS

GAS SHOW OF OIL AND GAS SHOW OF GAS SHOW OF GAS (WELL UNFINISHED)

UNPRODUCTIVE EXCEPTING SLIGHT SHOWS CORE-DRILL HOLE REPORTED UNFINISHED AND UNPRODUCTIVE.

Figs. 1 and 2.—SKETCH MAP OF THE FAYETTE GAS FIELD AND VICINITY

Showing two of the many possible guesses as to the structure of the rocks in this area which may be made from the available geologic data.

are based on estimated altitudes of the top of the base of the sandstone near the top of the wells and are therefore probably nearly correct.

In Figure 2 the contours are drawn upon the same surface and are based on the same facts as in Fig. 1, but these data are given a different interpretation. In this case the fact that the sandstone at Newton's Mill has a much greater dip at the point where it disappears beneath the Cretaceous cover, ¼ mile south of well C, than would be necessary to give it an even dip from this point to its next exposure near well E, suggests that a shallow trough occurs in the rocks between these two wells. This assumption is strengthened by the fact that no exposures of the sandstone could be found along the base of the river hill between the outcrops near wells C and E on this bed; therefore, it may be below valley level. The assumption of a syncline between wells C and E is also suggested by the fact that a change in the direction of the dip very probably occurs between wells E and K, and the resulting syncline might easily extend northeast into Sec. 3. If this is true the axis of the trough probably passes east of well D, and from it the beds rise gently toward the north, south, and east. This syncline would be a continuation of the one shown on the map in Sections 1 and 2, T. 16 S., R. 12 W.

These two sketches suggest that others might be drawn without contradicting any of the known facts regarding the structure. For instance, the shallow syncline shown in Figure 1 as having a north-south trend through Sec. 10 could be added with a slight modification to Fig. 2, without conflicting with any facts at present recognizable regarding the dip of the Pottsville beds in this locality; also because of the slickensides in shale bed No. 16 of well section E (Pl. II) a fault may be assumed to pass through this well with a northwest-southeast trend, thus changing entirely the local structure. There seems to be little question, however, that the Fayette gas field, as developed by the wells shown on the map, is located at a point where the rocks dip relatively steeply toward the south or southwest.

ECONOMIC FEATURES OF THE FAYETTE DISTRICT.

TESTS FOR OIL AND GAS IN THE FAYETTE DISTRICT.

As stated in the beginning of this paper, drilling in the Fayette district has resulted in the finding of gas in considerable quantities in Providence wells Nos. 1, 6, 8, 9, and 10. These wells are marked on the map by the letters G, I, H, S, and J, respectively. Nos. 9 and 10 (S and J) have shown more or less salt water, and the latter is said to have been badly damaged by injudicious shooting. The writer was given no records of Providence wells Nos. 11, 12, and 13 (R, P, and U) or any direct evidence as to their depth and the nature of the rocks encountered in them. So far as he knows they may or may not have been drilled to the Fayette gas sand. None of them shows oil or gas in paying quantities. Providence well No. 5 (F) is said to have been drilled first to about 1690 feet and later deepened to over 2200 feet. No record of the second drilling could be obtained. The bottom portion of the records of Providence wells Nos. 2 and 4 (D and C) which would be of greatest value are not given (See Plate II). The only positive data regarding the character of the gas sand in the immediate vicinity of the producing area are given in Providence wells Nos. 3 and 5 (L and F) and in the Fayette Gas Company well No. 1 (K), the records of which are shown on Plate II. These three wells have undoubtedly passed through the Fayette gas sand without finding gas in paying quantities. A well was also started about 4½ miles northwest of Fayette by the Providence Oil and Gas Company, but it is said to have been abandoned after being sunk to a depth of a few hundred feet. The well (M) of the Fayette Gas Company, situated 3 miles southwest of Kennedy, has not been completed at this writing, and no data regarding it are available, other than that given on Plate II.

The Woods well No. 1 (B) of the Alabama Central Oil and Gas Company, located on the railroad about 1½ miles west of Bankston, passed through the Fayette gas sand between 1350 and 1440 finding a slight "show" of oil and a little gas. Small "shows" of oil and gas were noted at many places in the Freeman well No. 1 (A), but at no horizon was it found in paying quantities*. The well (U) at Bankston was drilled to a depth

*See Appendix, page 66.

of about 800 feet by the Providence Oil and Gas Company and work on it suspended during the time the writer was in the field. Slight "shows" of oil and gas are reported from it.*

A well is being drilled by the Five Rivers Oil and Gas Company near Newtonville about 13 miles south of Fayette, but up to the present date neither oil nor gas in paying quantities have been reported from it. Another deep well was started near Reform about 25 miles southwest of Fayette, but no data relative to it is at hand. A derrick was built near Berry about 18 miles east of Fayette, but no drilling had been done here at the time field work in this district was closed.

Summing up the situation; the developed part of the Fayette gas pool is about 2,500 feet long by 1,000 feet wide and contains five producing wells with initial capacities ranging from probably 250,000 to 4,500,000 cubic feet per day. One of these wells (Providence No. 8, (H) supplies the town of Fayette with gas. The others are closed. The eight other wells drilled in search of gas within 2 miles of this pool and the six other holes drilled in the region have reported neither gas nor oil in paying quantities.

Future Prospecting in Western Alabama.

The following questions probably cover the crux of the oil and gas situation in Western Alabama from a commercial viewpoint.

(1) Is the Fayette gas pool fully outlined by the wells already drilled?

(2) From the indications shown by developments to date are pools of oil and gas likely to be found in the Warrior coal field and adjacent localities in the Gulf Coastal Plain?

(3) If the Warrior coal field offers favorable inducements for testing, where should the test wells be located?

The remaining pages of this report will be devoted to an attempt to answer these questions so far as the limited data available permit.

Probable Extent of the Fayette Gas Pool.

In answer to the first question, the Fayette gas pool does not appear to be fully developed, though it very probably is not a

*See Appendix, page 66.

large pool. There is no evidence available to show that a well located 800 or 1,000 feet due north of Providence well No. 8 (H) should not get gas, (*) and if this one should prove successful, gas or oil may reasonably be expected in other wells drilled along the strike of the rocks in this direction to beyond the Fayette-Sipsey road. The Cosmos well No. 1 (E) is favorably located for either oil or gas if the Fayette gas sand is soft and porous at this point. To the east, southeast, and south of the producing area Providence wells Nos. 11, 12, and 13 (R, P, and N) seem to mark strategic positions for tests. If these have all found the Fayette gas sand unproductive, the limit of the pool in that direction appears to have been reached unless a well located about 800 feet north of No. 9 (S) and the same distance southeast of No. 1 (G) should find a good quality of gas sand, in which case it may be productive. If this well should prove to be successful, a well located midway between Providence wells 11 and 12 (R and P) would have a chance for either oil or gas in paying quantities. Assuming the Fayette gas sand to be uniformly good over this area and that Providence wells 11, 12, and 13 have not been drilled to it, No. 11 (R) probably offers the best chances. No. 12 (P) seems less favorably located and the position of No. 13 (N) appears to be unfavorable. The latter will most likely furnish salt water from the gas sand. The wells R and E, when finished to the gas sand, should go far towards determining the extent of this pool, since, from structural indications, the area northeast of the producing wells is the most favorable. The prospects for an extension in this direction are greatly depreciated, however, by the failure of Providence well No. 5 (F) to find gas. This failure may have been due to a locally poor sand which, if soft and porous farther northeast, may again become productive. If either wells R or E should prove to be productive a well located 2,000 feet a little south of east of well E and the same distance from well R should go far towards determining the extent of the pool. Providence well No. 4 (C) should be drilled deeper as a test towards the north.

In brief the Fayette gas pool is probably not fully developed. The most favorable direction for its extension is toward the north from Providence wells Nos. 1 and 8 (G and H) and, if

*See Appendix, page 66.

the unfinished well E is successful, the trend of development should be east as well as north. The writer doubts, however, if this pool will be found to be a large one, especially if Providence wells Nos. 2 and 11 (D and R) have reached the Fayette gas sand.

Possibility of Oil Pools Occurring in the Vicinity of Fayette Gas Pool.

The presence of this gas pool cannot be taken as a sure sign that an accumulation of oil is located somewhere near it. Many large gas fields, without accompanying pools of oil, occur in other parts of the Appalachian region. Most oil pools, however, are accompanied by pools of gas, or else the oil is associated with gas in the same pool. In the Fayette gas pool there is little available evidence to suggest the direction in which a pool of oil is most likely to occur in the gas sand. Such meager data as exist seem to slightly favor the northwest quarter of Sec. 9, and to a much less degree the south half of the S. E. ¼, Sec. 9, and adjoining parts of Sec. 16.

"Shows" of oil and gas have been noted in a number of sandstone beds in the wells of the Fayette district, and it is possible that some of these may be found to contain pools of oil of paying size in this vicinity. The most favorable indications for oil appear to have been found in sandstones relatively near the surface. Of these Nos. 8 and 13 of Section E, Pl. II, appear to be the same sands that carry oil in the Brennen diamond drill hole (T) in the drillers' record of Section F, Pl. II. A study of the core of Cosmos well No. 1 shows that the oil has accumulated in the sandstone as a pool and that it probably only lacks more pressure and a more porous pay sand to furnish wells of commercial size. In a theoretical way the data furnished by this core are intensely interesting. Beginning within No. 5 of this section (E, Pl. II), a bed of dark gray shale is underlain by massive green shale (No. 6) which grades downward into fine greenish, micaceous sandstone (No. 7), which in turn changes abruptly to massive brown (discolored by oil) sandstone (No. 8), saturated with oil, which, sofar as the writer could detect, is of practically the same texture and hardness as No. 7, and is, in fact, a continuation of that bed. This sandstone contains no oil and continues down-

ward unchanged, except for thin sandy shale partings through No. 9. Below No. 9 the sequence described above is repeated, No. 10 being a dark, fine-grained shale, No. 11 a massive greenish shale grading into massive gray, micaceous sandstone (No. 12), and then into a coarser phase of the same bed (No. 13), saturated with oil, with a non-petroliferous sandstone (No. 14) below. A study of this core section leads to the conclusion that these oil horizons represent true accumulations, and that lack of pressure behind the oil, and of porosity in the sandstones in which it occurs, may be the only reasons why they do not furnish oil in commercial quantities. Sandstone No. 8 of this well appears to be a part of the sandstones Nos. 7 to 9, inclusive, of Section L, Plate II, in which good indications of oil were found. These facts suggest that this sandstone is oil-bearing over a considerable area and that in places where it is unusually coarse-grained and porous, small oil wells may be secured.

Another zone which shows more or less oil in almost every well, is marked by No. 22 and No. 24 in Section F, No. 16, Section G, No. 17 Section H, No. 22 Section I, No. 24 Section J, Nos. 17 or 19 Section L, and No. 11 Section M. Similar oil zones may be traced out on Plate II. These general oil zones indicate that the process of accumulation has gone on to a certain extent in this vicinity and also that the Carboniferous strata contain appreciable quantities of oil which at favorable places may have been gathered into valuable pools.

The writer thinks it very probable that other and larger pools of gas and oil exist at places in the Warrior coal field. This belief is based upon the age and character of the rocks which underlie this territory within reach of the drill. From these formations have been secured a large part of the oil and gas of Oklahoma, much of that of West Virginia, southeastern Ohio and portions of Pennsylvania. The general structure of the coal basin and the detailed structure, as shown by the small area mapped, apparently is as favorable as that of the great oil and gas regions mentioned above, with the possible exception that there may be too many faults in certain parts of the Warrior coal field to offer ideal conditions. From the scanty data available it seems that the general underground water conditions are such as to offer almost ideal opportunities for this most important factor of accumulation to exercise

its function. These facts, taken in connection with the known existence of one gas pool (though it may be a small one) and the presence of more or less gas and oil in sandstones at a number of points (indicating that the rocks have an appreciable amount of these hydro-carbons scattered through them) seem to show that all of the general geologic conditions considered essential for the formation of valuable accumulations of oil and gas are present in this region.

Favorable Areas for Testing Outside of the Fayette Field.

With but a very limited amount of data at hand relative to the age and character of the unexposed rocks of this region in which oil and gas pools might occur, and still fewer facts regarding underground water conditions, together with the lack of a map of the Warrior coal basin showing in detail the structure of the rocks, it is impossible to pick out with confidence small areas that are especially favorable places for testing. The area in which the structure of the rocks is shown on the topographic map, though large enough to indicate the character of the folds to be found in this region, is far too small to be of most value in determining the best places for future drilling in a prospective oil and gas territory as large as the Warrior coal field.

Gas in paying quantities has been found only in the Fayette field where it comes from a sandstone in the lower part of Pottsville formation. The few wells that have been drilled below this sand, though unproductive, can in no sense be considered as serious evidence against the possibility of valuable pools existing in the Mississippian series and even lower formations. If the oil and gas of this region have been subjected to the same general processes of accumulation as that of the Appalachian region farther north in New York, Pennsylvania, Ohio, and West Virginia, the accumulations in the upper sands will be found at places where those beds lie at a lower level than where the deeper horizons are productive. Therefore, if it is assumed that the Fayette gas sand is near the middle of the vertical section of oil and gas-bearing beds of this region, we should expect to find that the sands above this bed, which show oil and gas in the Fayette field, will contain the

largest number of paying pools at places where they are at a lower level, or toward the south and west. Conversely, if the Mississippian series or any lower formations are productive, the pools are more likely to be found at points where they are at as high, or a higher, level than they are in the Fayette field, especially if upon deeper drilling in the Fayette field these lower beds are found to be not productive and to furnish little or no salt water.

From this it is clear that there is absolutely no way of determining where drilling should be done until a detailed map showing the dip of the rocks over a considerable portion of the Warrior coal basin is available for study. With such a map and facts regarding the underground water conditions in a number of widely scattered deep wells of this region, the uncertainty regarding the best localities for testing would disappear. It is, therefore, highly important, from a business as well as a scientific point of view, not only that the geology of this region should be thoroughly studied, but also that the greatest care should be taken in future deep drilling to find out and record the water conditions of the beds. The kind of rock in which water is found, the kind of water, whether fresh or salt, the height to which it rises in the well, and its relative volume, are facts of prime importance in selecting those areas in which valuable pools of oil and gas are most likely to occur. In using this data the geologist bases his deductions upon the unquestioned laws of cause and effect, which have been more clearly worked out in other oil and gas fields that have been thoroughly developed. Such deductions, though based upon imperfect data in a new field (and therefore not unquestionable) when consistently followed, will always eliminate a greater or less percentage of the element of chance which is present, and which will probably always be present in oil and gas operations.

With the above limitations before the reader, the writer ventures to suggest that the area lying north of the Fayette district (Plate I) has not received the attention from drillers that it deserves; though in making this suggestion he does not wish to depreciate the value of testing in other directions.

From what is at present known of the geologic conditions of this region, it seems probable that the northern part of Fayette County, the western part of Walker, the eastern part

of Lamar, and all, or at least the southern portion of Marion, and the western part of Winston counties contain small areas in which all the conditions necessary to the occurrence of oil and gas are present.

This suggestion is advanced in the hope that future wildcat drilling will be more evenly distributed over the western part of the Warrior field and adjacent parts of the Coastal Plain. Such testing will not only more quickly determine the value of this region for oil and gas, but will also furnish very valuable geologic data which may be used to great advantage in restricting the areas that are worthy of thorough testing.

APPENDIX.

Page 58. a. The writer has been informed by Mr. H. G. May, superintendent of the Alabama Central Oil and Gas Company at Bankston, Alabama, that this well was drilled later to a depth of 2,932 feet without encountering oil or gas in commercial quantities, but no detailed record of the well other than that given on Plate II has been obtained.

Page 59. b. This well at Bankston station, which is Providence well No. 13, was later drilled to a depth of about 1,700 feet where a large quantity of salt water was encountered in what is thought to be the Fayette gas sand, and operations were temporarily suspended. Still later, drilling was resumed and a total depth of 2,050 feet reached. On June 22, 1911, gas was encountered in this well while drilling at a depth of about 2,050 feet, the hole being at that time filled with several hundred feet of water. The writer has been informed by Mr. James L. Davidson of Birmingham and Mr. H. G. May of Bankston that this well furnished a strong flow of gas with an estimated pressure of possibly as much as 800 pounds. Mr. Davidson guessed the flow at about 6,000,000 feet per day, but owing to the fact that the well stood at the last account with 2,000 feet of water in the hole, no definite figures have been obtained regarding the value of this find. Mr. Robertson of the Providence Oil and Gas Company expressed the belief that when the water has been successfully shut out of this well it will furnish gas in commercial quantities.

Page 60. c. The writer has been informed that a well has since been drilled at this location which has furnished gas in commercial quantities. He is not aware of other developments in this vicinity.

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